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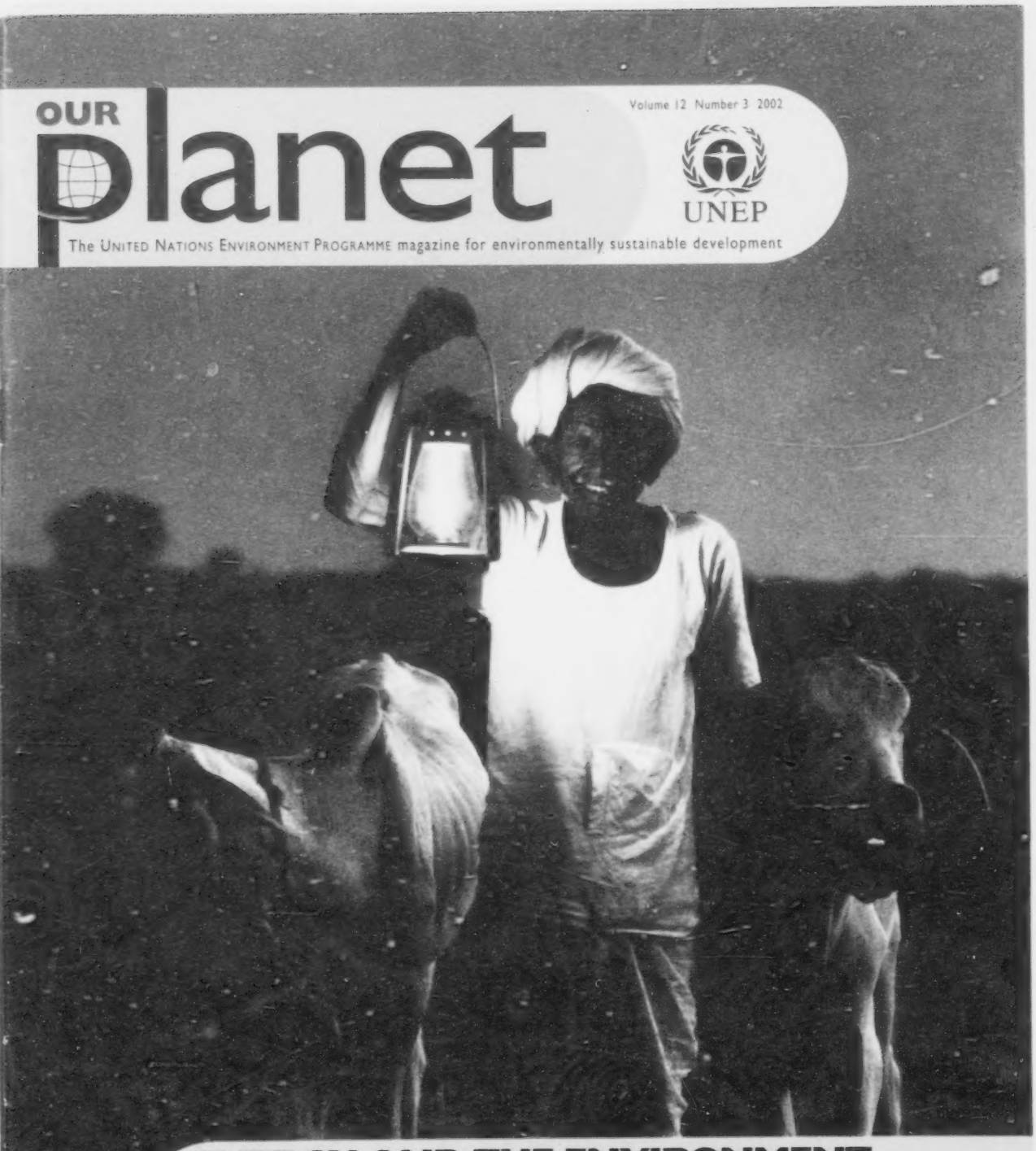

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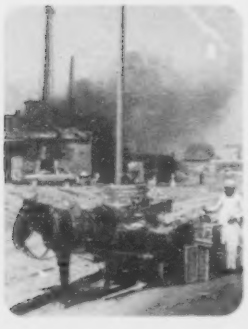

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Editorial

KLAUS TÖPFER
United Nations Under-Secretary General and Executive Director, UNEP

A pioneering project to map the solar and wind resources of developing countries from Latin America and Africa to Southeast Asia is now under way. The project, backed by UNEP, plans to pinpoint sites where solar cells and wind turbines can be deployed cost-effectively as part of an international effort to fight global warming and poverty.

Renewable energy's benefits are manifest: while manufacturing solar panels and turbines may emit greenhouse gases, these devices operate without pumping carbon dioxide and other pollutants into the atmosphere.

The costs of renewable energy have also tumbled in recent years, making wind and solar power cost-effective in many parts of the world, particularly rural areas without access to a traditional electricity grid.

Ongoing obstacles

Despite promising environmental, economic and development benefits, obstacles to widespread use still remain. Investors require accurate information on the likely levels of electricity a proposed site will generate. Here, the Solar and Wind Energy Resources Assessment (SWERA) project can help.

The sun and wind levels of 13 developing countries across three continents will be assessed and linked to GIS mapping systems with a $6.7 million investment from the Global Environment Facility. We hope this exercise will reduce uncertainty by enabling potential developers and investors to match suitable locations to the likely solar and wind resource – and that it will demonstrate that these countries have much greater renewable resources than is currently supposed.

It is timely. The G8 Task Force on Renewable Energy has drawn up recommendations on how alternative forms of generation could be delivered to over a billion people by 2010. Meanwhile agreements made in Bonn and Marrakech last year as part of measures to fight global warming have added new impetus.

I refer, of course, to the Special Climate Change Fund, the special fund for the least developed countries, new adaptation funds and the Clean Development Mechanism, all of which have grown out of the United Nations Framework Convention on Climate Change and its Kyoto Protocol.

Boosting confidence

Leaders, policy-makers and communities need to be given confidence in renewables, by being reassured that they are genuinely first-rate sources of electricity, superior not inferior to conventional ones.

So I welcome the Task Force's suggestion that 200 million of the 1 billion extra people expected to benefit from renewable energy systems should be in the industrialized world. This sends a clear signal that renewables have come of age and are truly ready to take their important place in providing more sustainable forms of electricity generation.

UNEP will work closely with ministers, officials and communities in developing nations and stands ready to advise them on how to best exploit green energy schemes and the opportunities provided by the Bonn agreements. We host the secretariat of the African Ministerial Conference on the Environment.

The new fund for least developed countries – set up to streamline the procedures for delivering green energy schemes of less than 15 megawatts – should also play a key role.

Voluntary effort

We are already seeing cleaner forms of energy generation across the globe. The World Energy Council in London recently estimated that voluntary actions by companies, organizations and governments are set to cut carbon dioxide emissions by a billion tonnes by 2005. It believes the real reductions could be as much as twice as high as new schemes come on line.

The outlook would not be so promising if it were not for the climate change agreements. All this voluntary activity is partly occurring because many industrialized countries are facing the need to reduce emissions both at home and through schemes in developing countries. Without deals in Bonn and Marrakech the impetus might well have faded away.

Some 2 billion people lack the energy they need to heat and light homes, pump water and keep medicines refrigerated. Even if the Task Force's ambitious recommendations are achieved, many will still be in desperate need. So we must also push hard to deliver cleaner versions of conventional fossil fuels. We also need intensive efforts to make electrical appliances, homes and cars less polluting and wasteful. Energy efficiency, all too often ignored, must be improved.

We stand on the threshold of a potential new beginning in the way we manage and care for our planet. Just like the energy we use, let us not waste it ■

SECURE and SUSTAINABLE

LOYOLA DE PALACIO outlines a strategy to meet the energy challenges of a changing world

Energy supply is the chief challenge among a number facing the European Union (EU) in the energy sector. Towards the end of 2000, the European Commission published a Green Paper on the subject, the springboard for a frank discussion on energy policy. This ongoing dialogue involves all the European players, not just the energy suppliers and the energy industry, but also consumers and the non-energy sectors, including politicians both inside and outside Europe.

The Green Paper's starting point is the EU's high dependency on outside countries for its energy supply; nearly 50 per cent of it comes from external sources. What is more, experts forecast that this will increase to as much as 70 per cent by the decade 2020-2030. And the situation is likely to worsen further with the enlargement of the EU, as it contends with rising demand, increased reliance on imported fuel, and the difficulty of reducing greenhouse gas emissions.

Strategy for the future

The Green Paper has prompted a major debate on the security of the energy supply, and the European Commission has itself put forward several ideas. First, it demonstrates that a proactive approach to saving energy is the first crucial stage in developing a sustainable energy supply policy. In the transport sector, which is nearly 100 per cent dependent on oil, improved management of demand could help reduce this massive reliance on fossil fuels. As with buildings, a wiser use of energy would lead to immediate reductions in greenhouse gas emissions. Conserving energy is thus one of the pillars of a sustainable supply. The second pillar concerns European policy regarding liberalizing internal energy and gas markets. Adopting electricity and gas directives and implementing them at national level have made it possible to reap considerable results with respect to opening up the markets to competition. Some obstacles remain, however, and much still needs to be done to guarantee the optimum functioning of the single market – and to achieve a harmonized market as opposed to the mere juxtaposition of 15 liberalized markets.

A proactive approach to saving energy is the first crucial stage in developing a sustainable energy supply policy

With this aim, the Commission proposed a new package of measures for completing the internal energy market in March 2001. This allows for opening up the electricity market for all industrial customers in 2003 – and for extending this to the gas sector in 2004 and to all residential customers in 2005. But this liberalization must take place within a regulated competitive framework. Each state will need to appoint an active body to monitor the market – that is, to maintain a balance between supply and demand, to anticipate developments, to forecast change, prospects and additional capacity requirements, and to keep an eye on the level of competition in the marketplace. It is essential for us that liberalization is not at the expense of the security of supply or to the detriment of public service.

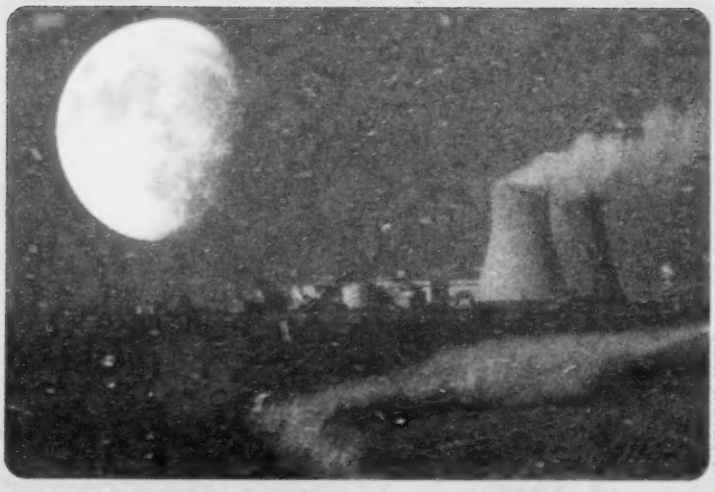
The third vital tool for a sustainable energy supply is technology. A whole array of technologies for cleaner energy generation and use exist. The massive growth of the European wind power industry over the last decade sets a promising example for other renewable energy industries. Similarly, European businesses are global leaders in clean coal technologies, which can cut emissions from coal-powered plants in half. Industry around the globe can benefit from our innovations.

As for nuclear technologies, the EU will pursue its technological research to ensure the highest safety standards and the best possible management of radioactive waste. It is my view that nuclear energy is vital to the future security of Europe's energy supply. It is not only a major factor in diversifying our supply, but also enables us to avoid producing hundreds of millions of tonnes of greenhouse gases. I believe it is essential to keep this option open if we are to meet the Kyoto targets.

Transparency and stability

Lastly, we would like to achieve greater transparency and, above all, greater stability in the energy markets. We can use existing structures to a certain extent, particularly by entering into a producer/consumer dialogue with oil-producing countries. We would also like to increase our collaboration with other key players in the energy sector. One of these is Russia, which has long been an energy partner and with whom we are building a strategic alliance.

The EU is already Russia's main business partner: energy represents 45 per cent of its exports to the EU in terms of value. Similarly, around 20 per cent of the EU's oil imports, and 40 per cent of our gas ones, come from Russia. So as part of our aim of liberalizing and integrating energy markets, we are examining – with Russia – the common interests in our energy relations and the areas where we can make real progress towards a partnership. At a meeting with President Putin in November 2001, we identified a number of specific short-



Rudolf de Rudder/UNEP/Topham

term actions and some major longer-term possibilities worth exploring at a later date. At the same time, we also hope to encourage collaboration with our partners in the southern Mediterranean, Latin America, Africa, the Caspian region and Asia.

International cooperation

In publishing the Green Paper, the European Commission hopes to place the energy supply strategy in its widest context – a global one. As recent international events have demonstrated once again, we must act in concert: tackling world problems requires a global vision. First, let me refer to geopolitical events. The events of 11 September 2001 marked the beginning of a new phase in international relations. Uncertainties caused by the terrorist attack in the United States, and by the ensuing response, will have an impact on the whole world, as well as on the regions directly affected. The impact on energy markets is far from being obvious, as the recent fluctuations in oil prices show. Secondly, the trends in energy demand have consequences for us all. Universal pressure on the limited global reserves of fossil fuels is likely to create problems for future generations. Take the exploitation of coal which, in some countries, is the preferred fuel for generating electricity. The technology exists to use it to do this more cleanly. Are we prepared to make the considerable investments necessary to benefit from it? Yet climate change demands it.

As for oil resources, the problem remains unchanged. All countries demand an improved standard of living, which increasingly relies on oil, especially for transport and electricity. But how can we satisfy needs without exacerbating climate change and jeopardizing the security of supply? Nuclear generation, which is low in greenhouse gas emissions, is an attractive option for electricity, but it must ensure the highest levels of safety and waste management, as an imperative.

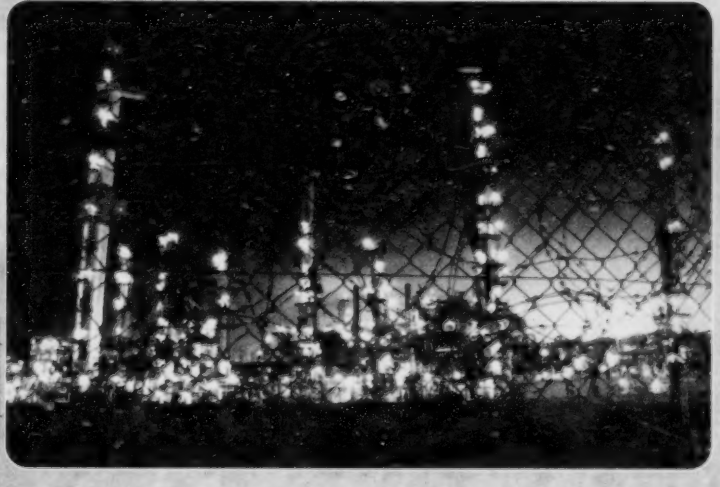
Conclusion

Those of us involved in energy policy have a responsibility towards our citizens. Their – *our* – way of life depends on having a reliable, affordable, clean supply of energy. But we also have a duty towards future generations. That is why we must develop sustainable visions that guarantee the supply while minimizing its impact on the environment, and use the resources available to us in the best possible way.

Each of our regions has much to offer. But the energy question is a global one which requires a global response. We must urgently tackle the problem head on and face up to the realities of the present. We must also go beyond our regional discussions and enter into a fruitful global dialogue, which alone will make it possible to maintain sustainable development and guarantee the next generations a future for our planet ■

Loyola de Palacio is Vice-President of the European Commission, responsible for Transport and Energy.

We must develop sustainable visions that guarantee the supply while minimizing its impact on the environment



M. Loquet/UNEP/Topham

M.E.P. Pena/UNEP/Topham

Fuelling multilateralism

BAGHER ASADI says that an internationalist approach can resolve differences between developed and developing countries over energy, climate change and sustainable development and build a sustainable future

The role of energy in the economic life of societies, particularly in modern times, is established beyond dispute, academically and otherwise. It has come to occupy a central role in almost all economic activities in all societies of our times, albeit to varying degrees depending on the level of industrialization and technological sophistication. Aside from the allure of pure nostalgic feelings for the simple, easy ways of life of a pre-modern past, we – wherever we happen to find ourselves on either side of the development divide – do consider energy as an irreplaceable ingredient for the economic/industrial activities of our societies. In the developed world, it is needed to keep the industrial/technological complex moving on, and to sustain and further promote the advanced way of life already achieved. In the developing world, it is an altogether different story.

Energy's paramount role in the economic life of societies is only one aspect – however important – of a much bigger picture. A few decades ago energy economics used to deal only with such fundamental concepts as competitive price, supply and demand and, in general, market-related matters. As a graduate student of economics at an American university in the mid-1970s, I can hardly remember even once hearing the word 'environment' in an energy context.

Now, it is totally different. The paradigm has changed, and changed substantially. The question that now confronts us is not merely that energy production and use have environmental impacts. That is given. Instead the issue – as in any other matter of global import and impact – has assumed far more complex dimensions. Current patterns of energy production and use, particularly those of fossil fuels which are considered highly polluting, are characterized as damaging to the environment, unhealthy, and hence unsustainable. This kind of message is heard from quite an important part of the industrial, developed world. Given their economic/industrial wherewithal and political prowess, not to mention their international/multilateral influence, they have succeeded quite largely in advancing their clean, green ideas and placing them effectively on the global agenda. Let me underline that there is nothing wrong with that *per se*.

Energy for the developing world, on the other hand, is, first and foremost, a 'development' issue. It is a matter of bread and butter for economic and social development. I tend to suppose it should now be rather axiomatic that development comes through growth, which in turn depends

on a higher level of economic activity and consequently an inevitable increase in the use of energy.

Energy, therefore, is essential for economic growth and development, and for the prospect of a better life for the citizens of developing societies. At the same time, however, it is deemed to be harmful to the environment and to the sustainable development of the planet. It is quite a predicament for these countries, which comprise almost two thirds of the world's population. And sheer statistics ruefully remind us that currently 2 billion people, mostly in developing societies, do not have access to modern energy services, particularly electricity. This is, of course, only one measure of the lack of development, or underdevelopment, in the greater part of the global community.

This dichotomy is one aspect of the energy picture. Another, equally important, relates to facts and figures, including hard scientific research and data. Science and economic forecasting tell us much about the parameters of the energy scene and about how it has been, and will be, developing on a global scale, including both developed and developing worlds. At one level, we have to reckon with the fact that energy use accounts for more than two thirds of the greenhouse gas emissions addressed by the Kyoto Protocol. And at another, as the Third Assessment Report of the Intergovernmental Panel on Climate Change points out, the average annual growth rates of primary energy consumption were 1.6 per cent for developed countries between 1990 and 1998 – and 2.3 to 5.5 per cent for developing countries. The indications are that energy demand in developing countries will increase further and that fossil fuels will probably provide the dominant means of meeting their needs. The same report also shows that developed countries were responsible for over 50 per cent of energy-related carbon dioxide emissions in 1998 – not a bad measure of their unsustainable patterns of energy production, consumption and distribution.

Long-awaited development

These facts and figures very clearly point to quite unsustainable global patterns and trends which no doubt do not portend a rosy outlook. But militating against a rather bleak future situation must not be at the cost of the developing world. Its countries cannot reasonably be expected to forgo badly needed economic growth and long-awaited development because of the dangers posed by the accumulation of greenhouse gases in the atmosphere. What these societies – and, to be more precise, their polity – have to deal with is much more immediate and close. The ever increasing demands of apparently hard-to-control growing populations – with all the attendant socio-political ramifications – pose much more formidable immediate tasks and challenges at home. In the face of the hard and harsh reality of underdevelopment – and all its attendant and associated ills, especially dehumanizing poverty –

Militating against a rather bleak future situation must not be at the cost of the developing world

Two billion people do not have access to modern energy services, particularly electricity

ameliorating greenhouse gas emissions could indeed look more like a leisure and luxury than a pressing need to many a developing society.

The dichotomy seems stark, and apparently irreconcilable. Looking, however, at the picture in the aftermath of COP-7 in Marrakech – and relishing that the Protocol is finally ratifiable – I tend to believe that there is a real possibility of a rather balanced approach to the questions of energy and climate change, and more generally, of sustainable development. There is an important, potent message in the very fact that the international community could – thanks to close cooperation between the developing world (G-77) and the European Union – overcome all the nagging difficulties and agree on a wide range of decisions, measures and mechanisms to render the embattled instrument ratifiable. Multilateralism and international cooperation work.

International cooperation

The same is true for energy and its long-term relation with, and impact on, sustainable development. The objective of 'energy for sustainable development' could become achievable through genuine international cooperation, which takes into due consideration both the requirements of developing countries for long-term development and the exigency of combating the consequences of environmental and climate change. This requires using a combination of energy sources and options, including developing renewable energies and improving energy efficiency. Developing advanced fossil fuel technologies in general – and ensuring their accessibility to developing countries in particular – should be an important ingredient of this overall approach and policy.

The closely related objectives of making energy sources available, accessible and affordable to developing countries depends, in the final analysis, on other requisite elements and conditions – namely, providing financial resources, building capacity, and transferring environmentally sound and economically viable energy technologies.

These objectives can and should be pursued at both regional and international levels. Various existing forums and channels – including the on-going international dialogue between producers and consumers of energy – should be utilized within the general framework of international cooperation.

I believe a genuinely multilateralist approach to the question of energy and climate change should be able, in the long run, to address it in all its diverse and multiple aspects and dimensions and to develop desirable, and yet viable, policies and measures acceptable to both developed and developing countries ■

Ambassador Bagher Asadi of the Islamic Republic of Iran is Chairman of the Group of 77.

Meeting GROWING NEEDS

FRANÇOIS ROUSSELY calls for a long-term strategy that is in the public interest

Energy is one of the central issues of the 21st century. We have to find a way of satisfying the growing needs of the human population – the vast majority still living in poverty – without plundering the resources that will be needed by future generations, without polluting our ecosystems or disrupting the biosphere, and without putting undue pressure on the energy-rich regions of the world.

The first problem we face is the explosion in demand, due both to the huge increase in population and to the efforts of some of the most densely populated regions of the world to develop their economies. In just one generation, the world population has increased by nearly 2 billion, a rise of 33 per cent. This has mainly taken place in developing countries where energy consumption is 0.8 tonnes of oil equivalent per capita, compared with 4.8 in industrialized ones. More than 2 billion human beings still do not have access to commercial energy.

The World Energy Council forecasts that global energy consumption will rise by 50 per cent between 1990 and 2020 unless there is a dramatic increase in poverty: electricity consumption is expected to double. And this would only be a partial narrowing of the gap between the energy use of the developing and industrialized worlds.

P. Guinard/EDF Typhon

Fortunately, there are abundant immediate energy resources: 250 years of coal reserves, 40 years of oil, 70 of gas. The problems mainly lie in making energy choices that are heedless of the future of the planet and its inhabitants. We all know that burning fossil fuels leads to massive emissions of greenhouse gases which risk disrupting the climate. We know that even if energy resources are plentiful, every particle of oil, gas or coal consumed today will be lacking tomorrow. We see that the unequal distribution of hydrocarbon resources around the world is already a cause of global conflict.

Nevertheless, fossil fuels are still used for most transport and other needs – including more than 60 per cent of global electricity generation. Since 1992 (the Rio Summit), carbon dioxide emissions have increased by an average 100 million tonnes a year. This presents enormous challenges. But we have no intention of giving up, and know what needs to be done to ensure sustainable development.

Green services

Experience in the industrialized countries has taught us that offering families and businesses – where energy efficiency is a major concern – 'green' energy services that meet demanding environmental criteria has become a commercial asset.

Developing countries will be able to skip the stage we went through for several decades, where the growth in industrial production went hand in hand with increased pollution – provided that we can ensure the transfer of efficient technologies to them. China's Beijing Blue project – in which the EDF (Electricité de France) group is involved – is planning to replace the capital's old coal-fired boilers with combined-cycle power plants fuelled with natural gas, thus massively reducing local pollution and greenhouse gas emissions. In Mali, where we are electrifying several villages, we are also distributing low-consumption lights. Access to energy requires access to efficient utilization technologies.

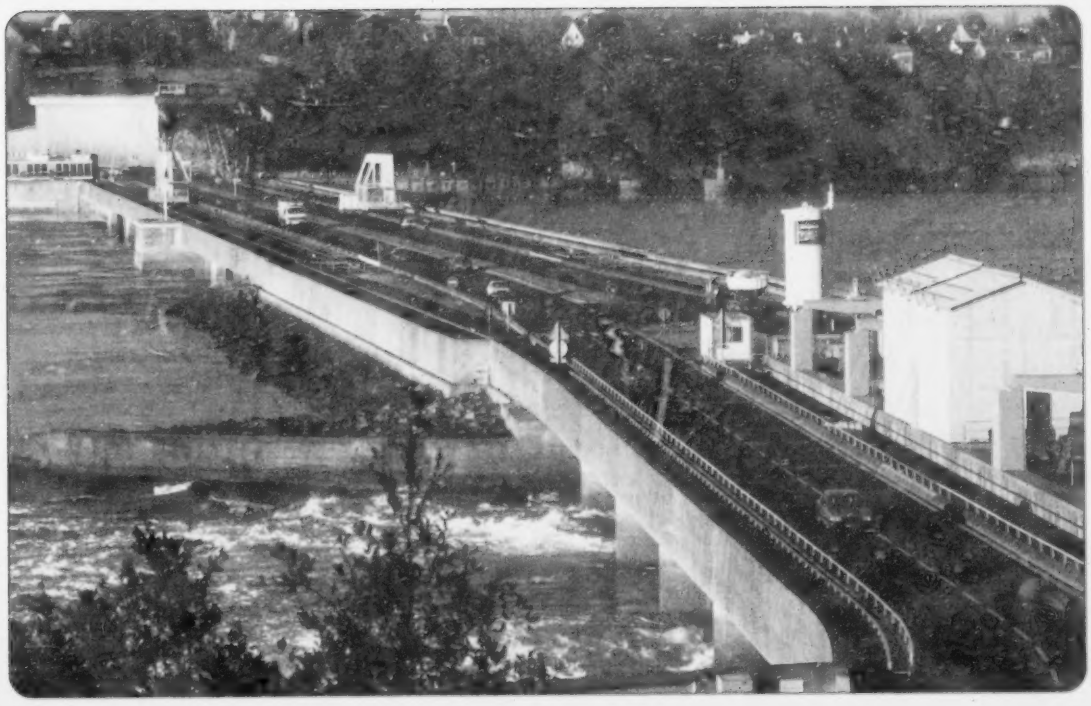
Fossil fuels will have to be used for a long time to come: their consumption will continue to rise even if we manage to reduce their relative proportion in the world's mix of fuels. That is one more reason for channelling oil consumption towards specific uses, and for confining energy generation to gas (which is cleaner) and, above all, to coal, whose abundance and distribution avoids geostrategic problems. The development of 'clean' technologies, such as fluidized beds and gasification, should reduce coal's environmental impact.

Renewables and nuclear

At the same time, we should be developing renewable energies, especially the first and most powerful of them, water. The world's hydroelectric power potential is far from being fully exploited.

The EDF group's experiments with wind power in Italy, the Caribbean and Morocco, with solar energy in Germany, France, Mali and Brazil, with geothermal energy in Guadeloupe and with biomass in France and Réunion demonstrate the economic viability of these solutions under certain conditions.

But we have to recognize that nuclear power and large-scale hydroelectric power plants are the only alternatives to fossil fuels for producing massive amounts of cheap electricity without greenhouse gas emissions. I believe that industrialized countries have a duty to use them – and to improve the technology and waste management processes – so as to enable the developing countries to access energy generation techniques that are easier to implement. Nuclear power remains the main method of electric power generation in Europe, where it represents 35 per cent of total output.



Michel Gaspard/Still Pictures

The world will build as many power plants in the next 20 years as it did in the entire 20th century. It is an opportunity to make the right investment decisions.

Although the necessary resources and technology already exist, we have to ensure that everyone can benefit from them. The globalization of trade is encouraging major energy groups to invest in developing countries. Formulae such as Build Operate Transfer (BOT) contracts allow a country to open its doors to investors who will hand over the power plants after operating them for 15 to 20 years. A number of our installations around the world are based on contracts of this kind. But the serious energy shortages in Brazil and California show that even strong growth areas are finding it difficult to achieve the necessary level of investment.

Giving access to energy to the world's poorest people requires appropriate solutions. We are developing these both in France and in deprived urban districts of South Africa and Latin America, by delivering a quality service and being profitable.

International development aid systems need to be strengthened and regulations introduced to favour the energies that spare fossil resources

Similarly, we have proved that it is possible to electrify remote villages using decentralized systems through local companies paid according to consumption.

Market forces

But these solutions are not automatic. Their success does not just come from market forces. Fierce competition can lead to a certain short-sightedness, and businesses are often forced to seek rapid returns on investment. This favours investing in thermal power stations rather than in hydroelectric energy – and, indeed, investing in something other than energy.

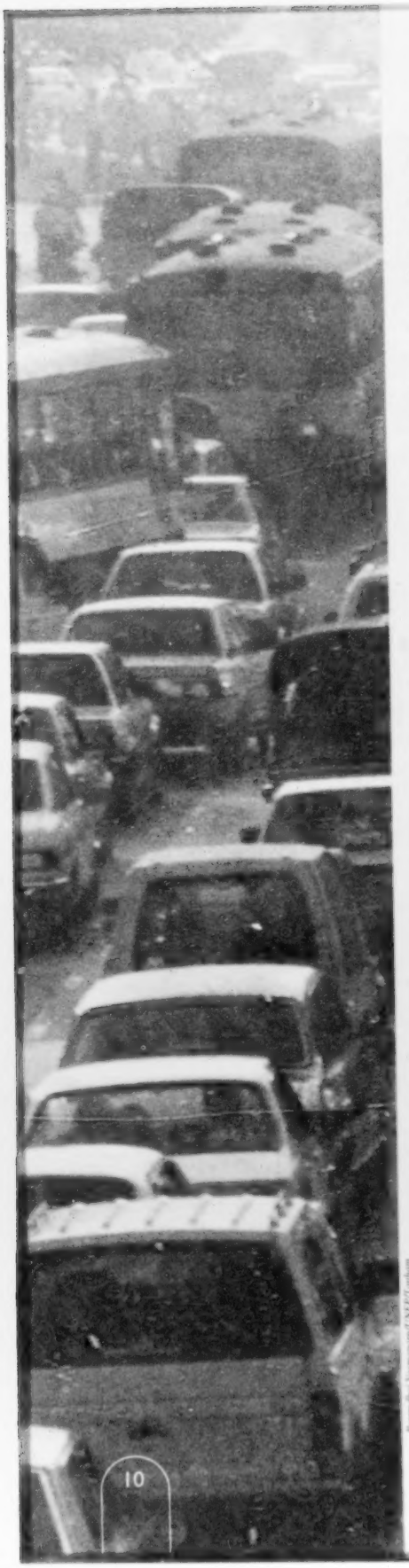
There was even a move to divide up large energy groups to encourage competition. This hindered economic efficiency and limited the capacity for research and development, vital for opening up new approaches like fuel cells or the use of hydrogen.

We have learned from experience that the success of BOT contracts or energy solutions for impoverished customers requires cooperation between the supplier, the authorities and community associations. Energy policy should not depend solely on private contracts. It concerns the whole community.

A willing, stable, just and democratic institutional environment is needed to guarantee long-term policy in the public interest. International development aid systems need to be strengthened and regulations introduced to favour the energies that spare fossil resources.

The energy industry demands plenty of space for considering public interest, as well as opportunity for debate ■

François Roussely is Chairman of Electricité de France.



Make way for the zero-litre car

JOACHIM MILBERG says that we must now decide on how to drive into the future and outlines how to enter the hydrogen age

What kind of fuel do we wish to use – or, more appropriately, will we have to use – to ensure our future mobility? This question is certainly not new: people in many countries the world over have been discussing it for years. But in the end the debate must lead to a conclusion. The BMW Group has made its decision. The time has now come for politics and business in general to make their decision too.

There can be absolutely no doubt that hydrogen is the fuel of the future. Companies and politicians in many countries agree on this obvious point. But harmony of opinion as such is not enough. Rather, we must now draw the necessary conclusions from this general consensus, and take specific steps to implement the hydrogen age. We need a strategy for establishing the necessary infrastructure, and one for introducing suitable vehicles to the market. The sooner we take these steps, the better.

Humankind already uses nearly a quarter of its primary energy for transport and the lion's share of this comes from fossil fuels. But the world's supply of fossil fuel resources is inevitably coming to an end: either through lack of availability or though strict policies deliberately limiting the supply of petroleum. Another factor is that carbon dioxide (CO_2) emissions from petrol and diesel vehicles are claimed to have negative consequences for our climate.

Securing mobility

All this presents a great challenge for the automobile industry. It is no longer enough for a car manufacturer to offer the customer attractive products. Rather, we must work to maintain individual mobility without recourse to fossil energy sources, and to secure the same standard of mobility for generations to come.

We must realize, in particular, that there is nothing to be gained from appealing to people to give up their mobility: human beings are simply not willing to forfeit the freedom they have come to appreciate. On the contrary, they will demand more and more comfort and safety in transport in the years to come. And they will also expect to get more enjoyment from driving.

But this is not just about satisfying personal needs. We must never forget that, above all, mobility is economically indispensable.

Reducing consumption

It goes without saying that we are working consistently to reduce the amount of petrol and diesel consumed by our cars. But this cannot provide an answer to the question of energy in the future. We will not find a genuine, sustainable solution if we simply continue to enhance and refine our existing technologies – which are already highly developed and sophisticated – no matter how great the technological and financial effort involved.

Instead we need an entirely new approach. We need new technologies that allow us to take a quantum leap in developing an entirely different potential.

This is why the three-litre, the two-litre or even the one-litre car is not our answer. In terms of CO_2 emissions, our answer is the zero-litre car, a car which does not consume petrol or diesel – the hydrogen car which we have already presented in a small production series following more than 20 years of painstaking research.

In May 2000 we unveiled a fleet of 15 hydrogen BMW cars in Berlin and it has been in everyday use ever since. We are proud of being the first car manufacturer in the world to develop

such a fleet, taking it out of the laboratory and on to our roads.

We are all the more proud of this achievement because hydrogen is the best option for a sustained – that is economically, ecologically and socially balanced – development process. Hydrogen generated by solar energy is the cleanest fuel available. I dare say, therefore, that our hydrogen-driven vehicle may well become the most important innovation in the entire history of the automobile. After all, this innovation means that we are driving in a car powered by sunshine and water.

We set out on our carbon-free road to the future to provide a sustainable, long-term solution in the interest of ongoing mobility. But we also decided to take this totally new approach to illustrate that sheer driving pleasure and responsibility for the environment are not incompatible, but two sides of the same coin. People wish to maintain and further enhance their sheer driving pleasure, so they will buy cars that offer both these assets at the same time.

Joining forces

Both the fuel-cell car being developed by other manufacturers and our own hydrogen-driven combustion engine run on hydrogen. So establishing a fully fledged infrastructure for hydrogen is a top priority. We must now join forces to concentrate on developing it. The question of which technology will be adopted in our cars is secondary, since ultimately the market will decide on whether the fuel cell with an electric engine or the combustion engine running on hydrogen provides the right path to the future. Our opinion on this issue is clear.

The BMW Group believes in the hydrogen-driven combustion engine, since it alone is in a position to maintain the high standard of auto-mobility to which we have grown accustomed over the last 50 years of individual, personal transport. The only change is that in future we will drive with a different, clean fuel. This is at the very core of our CleanEnergy strategy.

The new BMW 7 Series will be introduced with a hydrogen engine in the last third of the decade. I am confident that there will be a significant number of new BMW cars with hydrogen engines on the roads of Europe and Japan by the year 2020. We realize that the process of converting our current energy supply system to a new hydrogen economy represents a huge upheaval. After all, we will need an entirely new infrastructure for generating, distributing and storing hydrogen. The conventional supply networks will gradually lose significance and will have to be replaced by new structures.

To make the costs of this process bearable and acceptable, this 'revolution' in our energy system requires the right political conditions and framework. We will only be able to achieve this enormous task promptly and without undue friction if business and politics agree on their targets and move together.

Establishing a fully fledged infrastructure for hydrogen is a top priority

We appreciate that politics and the economy are making joint progress in Germany. But we must proceed on the global level. We need support from legislators worldwide to develop standard rules and regulations. We need similar support from different groups in society and public opinion leaders. The BMW Group is raising interest in hydrogen through its CleanEnergy WorldTour, and is getting positive worldwide feedback on the advantages of this new technology. We are confident of being on the right track.

The BMW Group, through new technology, has opened the gateway to a totally new kind of energy, which will ensure mobility in the years and decades to come. We made our decision. Now the decision on which way we want to go must become a joint one ■

Professor Joachim Milberg is Chairman of the Board of Management of BMW AG.

Power sharing

KADER ASMAL reports on how to maximize the benefits, and minimize the downside, of hydropower from large dams

For decades, we have agonized over how to provide a better life for the world's poor without destroying our cultural heritage and the natural environment. If market-led growth is suggested as the key to reducing poverty, how can we ensure that such growth is equitable without stifling it in the process? How can vested interests be persuaded to recognize common interests?

With my 11 colleagues on the World Commission on Dams, we spent two years addressing one of the most contentious issues of economic development. The dams debate contains many elements of the broader issues of growth, technology and equity – to name but a few – which characterize the big debates about how best to help bring about a fairer world for all.

Industry and individuals need electricity. Irrigated crops feed people and earn foreign exchange. Everyone benefits from clean water and by controlling floods.

When 2 billion people lack electricity in a world choking from airborne pollution, hydropower once seemed to offer a clean alternative in countries blessed with rushing rivers. But dams also have a downside. Plagued by cost overruns, they can contribute to unsustainable debt burdens. They cause 4 million people to be displaced each year. Environmental impacts can be devastating. And the sharing of costs and benefits is often inequitable.

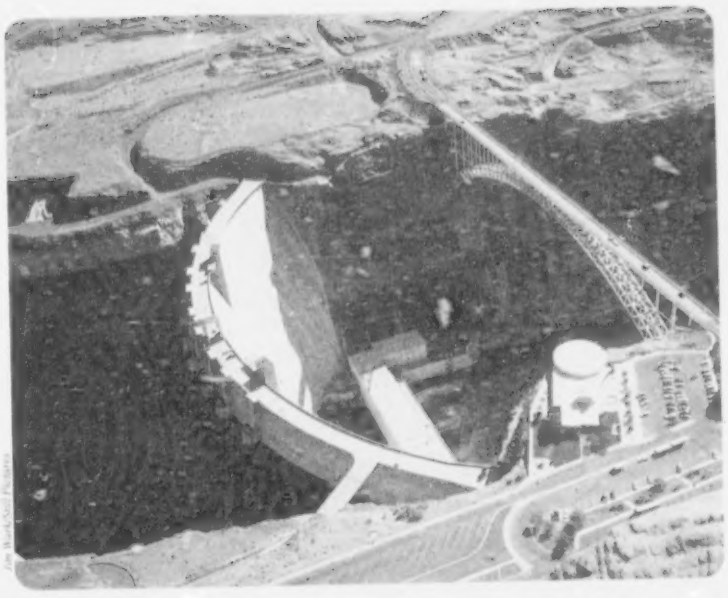
The challenge to our Commission was to find a shared set of criteria for deciding when and if a dam is the best option to meet a need and, if it is, to derive the benefits from dams while minimizing the negatives.

One third of the countries in the world rely on hydropower for more than half of their electricity supply, and large dams generate 19 per cent of electrical power overall. Electricity demand in developing countries continues to rise, and the range of choices to feed this demand is limited.

Effectiveness and alternatives

The Commission set out to review the development effectiveness of large dams and assess the alternatives for water resources and energy development. We undertook eight detailed case studies of large dams and prepared country reviews for India and China, plus a briefing paper on Russia and the newly independent states. A survey of 125 large dams was also developed, along with 17 thematic reviews on social, environmental and economic issues; on alternatives to dams; and on governance and institutional processes.

We learned that large dams built to deliver hydropower



had tended to perform close to but still below targets for power generation. They generally met their financial targets, but demonstrated variable economic performance relative to targets.

Ecosystem impacts were generally found to be more negative than positive for dams in general (including those designed for water supply, irrigation and flood control). They have, in many cases, led to significant loss of species and ecosystems. We found that all reservoirs that have been sampled by scientists emit greenhouse gases – as do natural lakes – from rotting vegetation and carbon inflows from the catchment area. The scale of these emissions is highly variable. Data from a hydropower dam in Brazil showed that the gross level is significant compared to emissions from equivalent thermal power plants. However, in other reservoirs (notably those in boreal zones) gross emissions of greenhouse gases are significantly lower than the thermal alternative. Clearly more research is needed to demonstrate the capacity for hydropower to offset climate change.

Benefits and impacts

We concluded that there was a need to look at proposed water and energy development projects in a much wider setting than had been typical in the past. This should reflect full knowledge and understanding of the benefits and impacts of large dam projects and alternative options for all parties. We called for a fundamental change in the way these decisions are made.

Decisions about power generation must be shared between the powerful and the powerless

In our report and recommendations, five core values emerged as being fundamental to informing the planning of future dams: equity; efficiency; participatory decision-making; sustainability; and accountability.

Armed with these values, we proposed an approach based on recognizing rights and assessing risks – particularly 'rights at risk'. We considered that this should be the basic tool guiding future planning and decision-making. We felt that this would provide a more effective framework for integrating the economic, social and environmental dimensions for assessing options and for the planning and project cycles associated with large dams.

We then identified five critical decision points when water and energy options are considered. The first two relate to planning:

- **Needs for water and energy services must be assessed and validated.**
- **The full range of options must be reviewed in order to identify the preferred development plan.**

When a dam emerges from this process as a preferred development alternative, three further decision points occur:

- **During the project preparation phase, it must be verified that all agreements are in place before the construction contract is put out to tender.**
- **During the project implementation phase, compliance with agreements must be confirmed before the dam is commissioned.**
- **During the project operation phase, the operating of the dam should adapt to changing external circumstances.**

Each of the five decision points represents a commitment to actions that govern the course of future conduct and the allocation of financial and other resources to the project. They are points where ministries and government agencies need to test compliance with preceding processes before giving the green light to the next stage.

Our report offered a new policy framework with fundamental departures from the approach much of the world currently uses. We are gratified by the way the report has been received and pleased that, although our mandate was finite, with a clear two-year time limit, the work of the Commission will be continued through the Dams and Development Project (DDP) under the auspices of UNEP, which will promote and support inclusive and informed multi-stakeholder dialogue on the issues raised by our Commission.

Decisions about power generation must be shared between the powerful and the powerless. We hope that the work of the World Commission on Dams will prove to have helped redress that balance ■

Professor Kader Asmal, South Africa's Minister of Education, was Chairman of the World Commission on Dams.

OIL and **RISING WATER**

SHEIKH HAMDAN BIN ZAYED AL NAHYAN says that Middle Eastern oil producers have an obligation to future generations to tackle the causes of global warming

Uptown Summit/ NPI Pipeline

The compromise agreement on climate change reached in Marrakech last November was welcome news. We must now hope that this will translate into tangible and speedy action to address the causes of global warming. We have seen too many deadlocked conferences where reluctance to give anything up has caused the threat to human livelihoods from rising temperatures to go on steadily increasing.

In her introduction to the 1987 report of the World Commission on Environment and Development, Gro Harlem Brundtland wrote: "If we do not succeed in putting our message of urgency through to today's parents and decision-makers, we risk undermining our children's fundamental right to a healthy, life-enhancing environment."

Heeding warnings

In the Middle East, we have a special need to pay attention to these warnings. As many of the countries of the region are low-lying and short of water, we are under threat from rising sea levels and desertification. Earlier this year the Intergovernmental Panel on Climate Change concluded that by the end of this century sea levels could rise by as much as 88 centimetres. This could flood not only coastal areas of the United Arab Emirates (UAE), but also much of the heavily populated Nile Delta in Egypt and the lower reaches of the Tigris and Euphrates river system in Iraq.

In the UAE, we are still a 'developing' country even though we are blessed with the wealth bestowed on us by our oil and gas reserves. We are conscious that, in the process of funding our ambitious development programme, we have a responsibility not only towards our own environment, but also towards that of the planet.

Environmental threats have traditionally accompanied the production of oil. We have made considerable strides in recent years to mitigate these dangers. One major achievement has been a dramatic reduction in the flaring of gases from onshore and offshore oilfields. In 1995, some 7 million cubic metres of gas were flared in Abu Dhabi every day. Today, we are down to 1.5 million – a 78 per cent reduction in just five years. Our objective is zero.

Capitalizing potential

We are also anxious to capitalize on the potential for renewable sources of energy like solar power. The results from research into capturing clean energy from the sun through a new generation of solar panels are encouraging. Before long it will be possible for us to construct buildings with photovoltaic panels that will generate most of their own energy requirements.

In the UAE's major onshore and offshore oilfields there is now a legal requirement for environmental baseline studies and impact assessments and to establish effective continuing monitoring programmes.

All projects proposed by the Abu Dhabi oil sector, as well as those put up by the various Government departments, must be approved by our Environmental Research and Wildlife Development Agency, of which I serve as Deputy Chairman. In fulfilling this requirement, we examine the results of the baseline studies and environmental impact assessments, and also take into account, where appropriate, both archaeological and palaeontological issues.

As a result, a number of major oil sector projects have had their original engineering designs changed in order to limit environmental impacts, through, for example, the drilling of clustered wells from a single hole and the increased use of directional and horizontal drilling. This leads to a win-win situation as it has put the UAE oil sector at the cutting edge of new drilling technology.

Our heritage is one of a people who could only survive in our fragile desert environment by learning to co-exist with nature and by developing a sustainable use of the resources available to us. Otherwise our ancestors would have starved. We recognize that today we have a global obligation to future generations and we are determined to play our part in securing the sustainable development they require ■

Sheikh Hamdan bin Zayed Al Nahyan is Minister of State for Foreign Affairs of the United Arab Emirates and Deputy Chairman of Abu Dhabi's Environmental Research and Wildlife Development Agency, ERWDA.

Energetic challenges

Connecting the 2 billion people who have no access to commercial energy is the most important energy challenge facing the world community. Women and children, primarily in developing countries, spend their days collecting wood or cow dung for fuel for cooking and heating their homes in very inefficient stoves: this both harms the environment and directly threatens the health of their families.

Outmoded boilers linked to central heating systems in most of the cities of Eastern Europe and the former Soviet Union pose another challenge. They are inefficient; they lack modern pollution control; and the end use of the heat is not metered, leading to more inefficiency and waste.

Both of these problems cry out to the world for investment. Investing in energy solutions in these countries can bring about significant and immediate local environmental improvements, achieve greatly improved energy efficiency, and substantially reduce greenhouse gas emissions. But, energy and environmental policy tends to direct investment towards industrial countries, even though it would have a greater impact on the environment – not to mention on the human condition in general – in the developing countries and transition economies.

Chip Hires Otto/UNEP/Topham

Supoki Tiyawatthanaphong/UNEP/Topham

We need a new direction in energy policy. The World Energy Council has studied the needs and we believe a number of our proposed policy recommendations would lead towards greater investment in the countries where it is most needed.

The political risk of key energy project investments must be addressed both by the countries seeking outside investment and by the global community at large. The countries must create an investor-friendly climate, which includes the rule of law and recognizes private property rights. The global community can contribute by developing new political risk insurance schemes rewarding the countries that create this climate.

Energy must be priced to cover costs and ensure payment. In too many countries, blanket subsidies for energy benefit those most able to pay, while doing little for the poor. The subsidies encourage energy waste and inefficiency and put unnecessary pressure on government budgets, diverting spending which could be more effectively deployed elsewhere or used to reduce borrowing. Energy programmes must be redesigned to target the poor precisely with subsistence amounts of energy, while the majority pay the full cost needed for a healthy energy industry.

Finance and goals

The world community should foster financing partnerships linked to environmental goals – emission trading systems, which would allow countries and companies to divert investment in pollution control and greenhouse gas reduction measures from industrial economies to developing and transition ones, where much more could be accomplished with the same amount of money.

Finally, affordable energy should be assured for the poor as a complementary measure to eliminating subsidies. Again, what is needed is more precision in assisting the poor, not less assistance to them ■

Jim Adam
Chairman of the World Energy Council

Energy powers economic growth and access to it is vital if poverty is to be alleviated. But it is very unequally consumed. The world's richest countries, with about a fifth of the world's population, account for over half of commercial energy use. Meanwhile some 2 billion people – one in every three inhabitants of the Earth – have no access to modern energy at all. They have to rely on such traditional fuels as wood, crop wastes and dung.

Most energy use – by both rich and poor – damages the environment. Burning fossil fuels is the main source of carbon dioxide, the most important greenhouse gas; it also gives rise to acid rain and health damage through air pollution. Meanwhile burning traditional fuels fills the homes of the poor with toxic smoke, taking an enormous toll in deaths each year.

But there are positive ways ahead. More and more studies suggest that rich countries could actually reduce their use of energy – and continue the same level of economic growth – through dramatically increasing its efficiency. Clean renewable sources offer increasing promise both for cutting pollution and meeting the needs of the poor. Over the next two decades up to $15 trillion will be invested in new long-term energy facilities. Much will depend on how it is spent.

Geoffrey Lean

UNEP/Typhoon

COAL *fuelled the Industrial Revolution in developed countries. It still provides about a quarter of the world's commercial energy, and generates about two fifths of its electricity. Its use is declining in most industrial countries, and China, the world's largest coal user, has also recently cut consumption. There is no shortage of resources, which could last for hundreds of years. The problem is that coal is the dirtiest of all sources of energy, emitting the most carbon dioxide and other air pollutants. However, new technologies for burning it cleanly are being developed.*

UNEP/Typhoon

Two billion people still depend on **BIOMASS** *fuels, such as firewood, crop wastes and dung for cooking and warmth. Gathering them is often massively time-consuming, backbreaking work, while burning them creates the world's deadliest air pollution: every year more than 2 million people die from breathing the cocktail of chemicals given off when they burn.*

Darren Defurt/UNEP/Typhoon

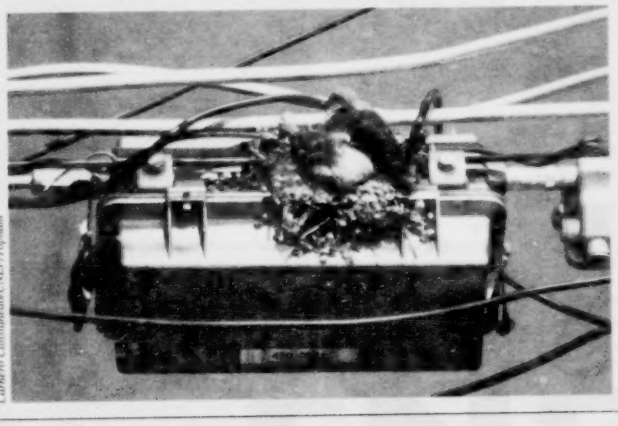
OIL AND GAS *between them account for about two thirds of the world's commercial energy and have powered most of the economic growth of the last 50 years. Their use is still increasing, and is expected to go on growing. But burning them, too, produces carbon dioxide and other pollutants. They fuel virtually all the world's vehicles, but an increasing number of experts expect them to be replaced by hydrogen by the middle of this century.*

Joerg F Dohmen/UNEP/Topham

RENEWABLE ENERGY *provides about 4 per cent of the world's commercial energy; half of this is contributed by hydropower. Wind and solar power are the fastest growing sources of renewable energy, but from a very low base. In theory they could meet humanity's energy needs many times over, and do so cleanly – but it is unclear how quickly they will be developed. Estimates of their share of the world's energy supplies in the second half of this century range from about 20 per cent to over 50 per cent.*

The world's 435 **NUCLEAR** *reactors produce about 6 per cent of its commercial energy, generating 16 per cent of its electricity. But this share is now expected to decline. Few new power stations have been built in the past 15 years: none have been ordered in the United States, for example, for over two decades. Nuclear energy is less polluting than fossil fuels, and produces no greenhouse gases. But fears of the consequences of accidents (particularly after the 1986 Chernobyl disaster), failure to solve the problems posed by its wastes, rising costs and entrenched opposition have frustrated its early promise.*

UNEP/Still Pictures



Cathryn Constantine/UNEP/Topham

ENERGY EFFICIENCY *is often called 'Cinderella energy' because it is widely ignored. Yet its immediate potential is far greater than any of the sources of supply. Technologies already available make it possible to cut energy consumption by half in existing industrial installations for example, and by 90 per cent in new ones. Studies have suggested that developed countries could reduce their energy consumption by two thirds without penalizing economic growth.*

What UNEP is doing

Dirk Bunsdale/UNEP/Topham

UNEP has been concerned with energy from its foundation, more than a quarter of a century ago, because using and producing it causes a wide range of environmental problems. UNEP helps countries meet the challenge of sustainable energy and enables decision-makers better to understand the links between the energy choices they face and broader issues of sustainable development. Its efforts are primarily directed at developing countries.

UNEP's goal is to insert a longer-term, environmental dimension into energy sector decisions. It works with a wide range of partners to develop and implement approaches for analysing energy policies, options for mitigating climate change, reform in the energy sector, energy efficiency in industry, and the environmental implications of choices in transport.

A special effort is made to help financial institutions better understand the good opportunities there are in investing in renewable energy and energy efficiency projects. A new UNEP partner, the Basel Agency for Sustainable Energy, is instrumental in this.

Strengthening networks

Much of UNEP's work is done jointly with energy-environment-development institutes worldwide, and we are strengthening this informal network. Another strength is the UNEP Collaborating Centre on Energy and Environment; its international group of scientists, engineers and economists provides technical and analytical support to UNEP and partners in developing countries.

UNEP's energy projects and activities include:

- The African Rural Energy Enterprise Development Initiative (AREED), which enables the private sector to deliver affordable services based on clean and renewable energy technologies in five African countries. A similar initiative has started in northeast Brazil.
- The Energy Management and Performance Related Energy Savings Scheme (EMPRESS). This project is helping establish specialized energy service companies to help industrial and commercial clients in Central and Eastern European countries.
- Efforts aimed at helping sub-Saharan African governments with reforms to the power sector and energy subsidies, energy sector finance and climate change policy.
- Creating a Network of Energy 'Centres of Excellence' promoting sustainable energy approaches through coordinated programmes of policy analysis, practical advice, targeted research and investment promotion.
- Working with financial institutions, insurance companies and Export Credit Agencies, to explore ways to direct finance and investment flows to sustainable energy projects, particularly in developing countries.
- The Renewable Energy Technology/Energy Efficiency Investment Advisory Facility, which helps financial institutions evaluate potential renewable energy or energy efficiency investments in developing countries and countries with economies in transition.
- Working with rural Indian finance institutions to develop a credit facility for solar system purchases, using United Nations Foundation resources.
- Managing a Mobility Forum for discussion and joint activities involving representatives of major automotive manufacturers ■

Win the AAAS Atlas of Population and Environment

Answer these three questions (you can find all the answers in the centre pages of this issue of *Our Planet*) and tell us in not more than 15 words what are the best ways of meeting energy needs while cutting pollution.

1. How many people worldwide lack access to modern energy sources? _____
2. Which is the dirtiest source of energy? _____
3. What proportion of the world's commercial energy is provided by renewables? _____

First prize: **American Association for the Advancement of Science *Atlas of Population and Environment***. Three runners-up prizes of UNEP's ***Focus on Your World*** postcard book.

'I believe the best ways of meeting energy needs while cutting pollution are _____

_____

_____

My name _____

Address _____

_____

_____

Entries must be received by SMI, PO Box 119, Pin Green, Stevenage, Hertfordshire SG1 4TP, UK, or energy@ourplanet.com no later than **1 April 2002.**

The winner and runners up will be chosen by a panel consisting of UNEP's Executive Director, its Director of Information, and the Editor of *Our Planet* from the entries received. The decision of the judges is final. This competition is closed to all those working for UNEP, Banson, AAAS, Robquestprint, SMI, and all other companies and organizations associated with the production of *Our Planet* magazine and their families. A full set of rules is available on application from energy@ourplanet.com

POWER TO THE PEOPLE

CORRADO CLINI describes how renewable energy is a key resource for combating poverty and protecting the environment

The total supply of primary energy worldwide is expected to increase by 30 per cent between 1997 and 2010, and by nearly 60 per cent by 2020, according to the projections of the International Energy Agency's *World Energy Outlook 2000*. In 1997, slightly more than 1 billion people living in the industrialized countries consumed about 54 per cent of the world's total energy supply, while around 5 billion people in developing and transition economies consumed the remaining 46 per cent. By 2020, the OECD countries' share is expected to decline to 44 per cent.

World demand for electricity is growing more rapidly than for any other end use, and – at an average growth rate of 2.8 per cent a year – it will almost double over the 1997-2020 period. Growth will be particularly high in developing countries, and is projected to be 4.6 per cent annually, compared to 1.6 per cent in the OECD. Nevertheless, per capita electricity consumption in the developing world will still be only one sixth of the OECD level.

A 'business as usual scenario' – based on energy policies in place in mid-2000 and consistent with the *World Energy Outlook 2000* reference scenario – suggests that during the period 1997-2020:

- Dependency on fossil fuels will grow, and carbon dioxide emissions from energy use will increase by a projected 60 per cent – over two thirds of this in developing countries.
- Renewables will be the fastest growing of all types of energy. However, because they are starting from only a small base, their share will only increase from 2 to 3 per cent of the world energy portfolio by 2020.
- Nearly 2 billion people – up to 30 per cent of the world's population, and all in developing countries – will continue to have no access to electricity. Improved energy services are unlikely to reach those who at present lack them.

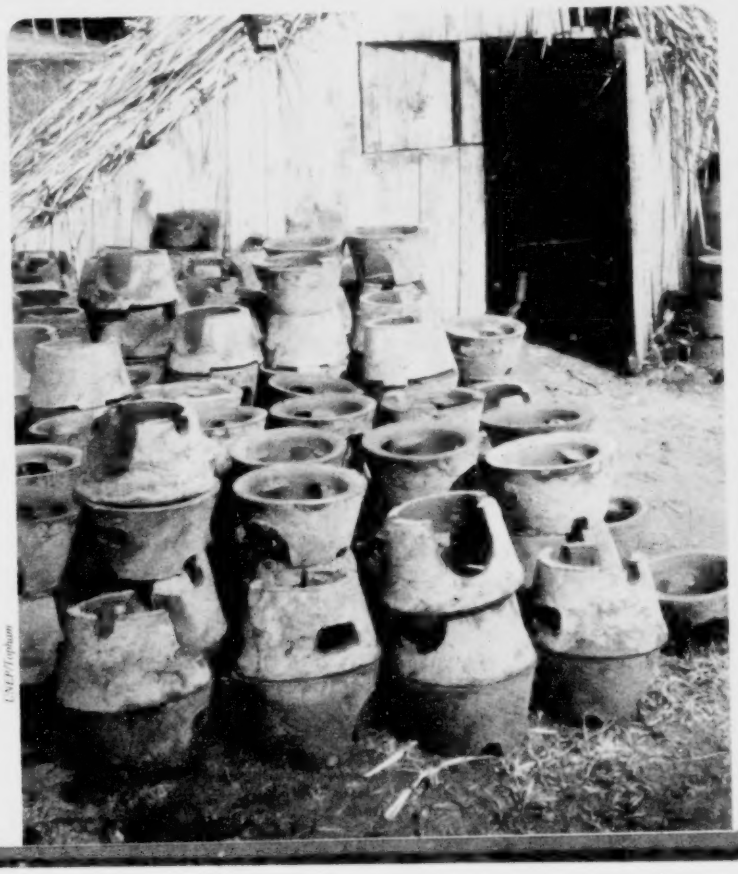
World demand for electricity is growing more rapidly than any other end use

This scenario will not result in a sustainable energy future. Poverty cannot be eradicated without adequate energy supplies in the developing world. Commercial energy services would allow a better quality of life for the poor, better education opportunities, better health conditions, better information, the dissemination of telecommunications and digital technologies, local industrial development and higher productivity. Traditional energy systems based on fossil fuels cannot meet the growing demand for electricity and increasing needs for access to modern energy services in the developing world without greatly increasing pressure on the environment, natural resources, public health and international relations.

Renewables and efficiency

Renewables are widely expected to play an increasingly important role in the world's energy portfolio – along with greater emphasis on energy efficiency – as it moves towards a sustainable energy supply.

With this in mind, the 2000 G8 Summit in Okinawa called for the ▸



UNEP/Topham

formation of a multi-stakeholder Task Force to assess the barriers to the use of renewables in developing countries and to recommend actions to better encourage it. Mark Moody Stuart, then Chairman of the Royal Dutch/Shell Group of Companies, and I were appointed as its co-Chairs.

The Task Force was formed by the representatives of G8 governments and members from 12 other countries (Antigua and Barbuda, Bangladesh, Brazil, China, Denmark, Egypt, India, Malaysia, Morocco, Republic of South Africa, Sweden, Thailand). The private sector, the multilateral financial institutions, and non-governmental organizations with experience in micro-credit all provided input on financial thinking.

The principal finding of the Final Report was:

> ***'Renewable energy resources can now sharply reduce local, regional, and global environmental impacts as well as energy security risks, and they can, in some circumstances, lower costs for consumers'.***

In developing countries, the new technologies of wind power, biomass energy, geothermal energy and small-scale hydro are often the lowest cost option to supply electricity to places unconnected to the grid, and are increasingly competitive in certain conditions on the grid. Meanwhile new solar technologies – photovoltaics, thermal power and heating – can play more than a niche role in many circumstances. In developed countries, the risk of supply interruptions – due to oil crises or to the insecurity of the electricity system – has increased over the last years, bringing new and additional costs. Renewables embedded in the grid can address this by being targeted to distribution system locations to alleviate load stresses more cheaply than by installing new generation and distribution assets.

Barriers to competition

The cost of renewable energy has fallen over the last decade, but in most cases it is not yet directly competitive with conventional alternatives. This is due to a number of key barriers, including:

- Insufficient human and institutional infrastructure.
- The high up-front costs of renewables, and other impediments to mobilizing capital.
- Weak incentives and inconsistent policies in comparison with the subsidies that encourage conventional energy.

In order to address these barriers, the Final Report recommends:

- Reducing technology costs by expanding markets: developed countries should implement existing and proposed national plans to expand domestic renewable energy markets in order to drive down costs and underpin the development of markets in developing countries. Working with both public and private sector participants, OECD countries should develop renewable energy projects where (i) renewables are a least-cost option on a life-cycle basis and/or (ii) renewables achieve protection of the local and/or global environment at a reasonable cost.
- Building a strong market environment: renewables should be adequately considered as part of energy policy in assessing the development priorities of countries participating in poverty reduction programmes.
- Renewable energy industries should be supported for the creation of joint ventures and other manufacturing, assembly and distribution/installation capabilities in developing countries.
- Mobilizing financing: official development assistance, bilateral and multilateral agencies should explicitly consider renewables for development projects and choose them when they are the least-cost option on a life-cycle basis.
- Encouraging market-based mechanisms: the OECD should develop national and international renewable certificate trading schemes, take steps to remove incentives and other supports for environmentally harmful energy technologies, and develop and implement market-based mechanisms that address externalities, enabling renewable energy technologies to compete in the market on a more equal and fairer basis. If we did all of these things, what might the result be? We could have an aspirational target of serving up to an additional billion people with renewable energy in the next decade.

Broken down, the aspirational target of a billion people includes:

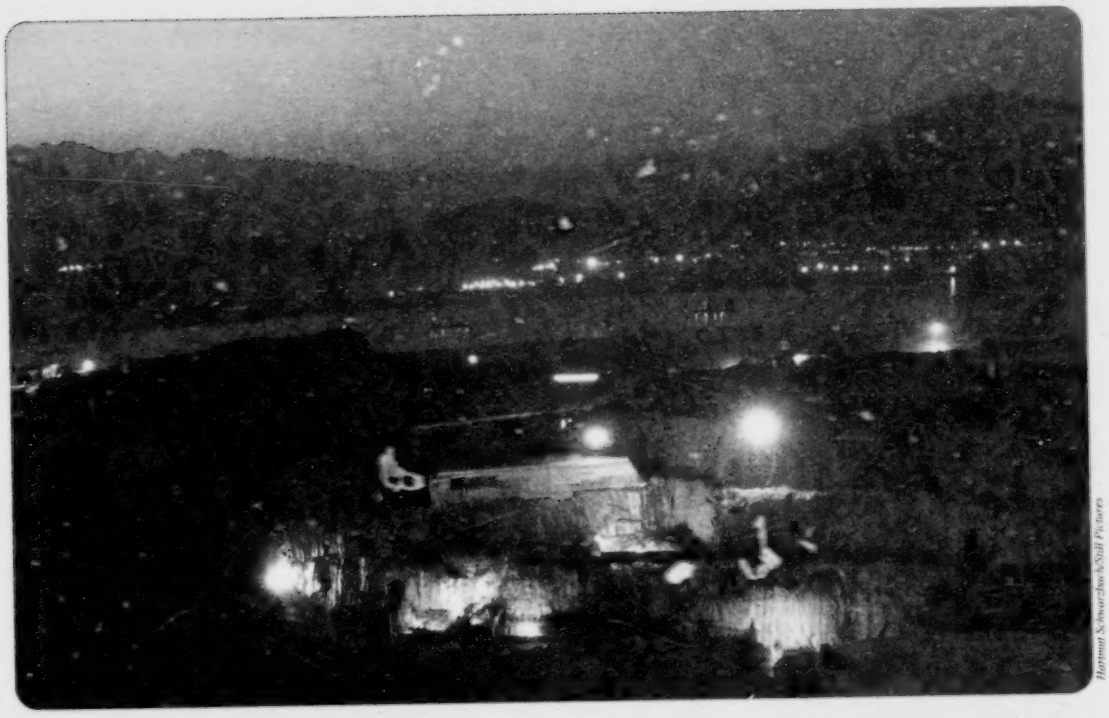
- 200 million through improved biomass-efficient burning stoves.
- 300 million through rural electrification, corresponding to 15 terawatt hours/year: a very challenging target.
- 300 million grid-connected in the developing world, corresponding to 180 terawatt hours/year.
- 200 million grid-connected in the OECD, corresponding to 600 terawatt hours/year; the size of the market in OECD countries will drive down the cost of the renewables globally.

G8 conclusions

These targets are consistent with the Genoa 2001 G8 Summit conclusions, to:

- Ensure that renewable energy sources are adequately considered in our national plans and encourage others to do likewise.
- Encourage continuing research and investment.
- Help developing countries strengthen institutional capacity and market-oriented national strategies that can attract private sector investment in renewable energy.
- Call on multilateral development banks and national development assistance agencies to adopt an innovative approach and to develop market-based financing mechanisms for renewable energy.
- Urge the Global Environment Facility to continue supporting environmental protection on a global scale and fostering good practices to promote efficient energy use and the development of renewable energy sources in the developing world ■

Corrado Clini is Director General of the Italian Ministry of Environment and was co-Chair of the G8 Task Force on Renewable Energy.



Hanna Schwarz/Still Pictures

Cutting carbon

YE RUQIU describes China's remarkable achievement in cutting energy use and carbon dioxide emissions while both its economy and its population grew

Energy is important for developing national economies. Traditionally, as this development takes place, the demand for energy increases. But exploiting and using energy resources intensively can damage the environment.

Since 1978 – when the policy of opening up and economic reform was first implemented – China has experienced rapid economic growth: its GDP has grown at an average rate of about 10 per cent a year. For most of this time, energy production and consumption kept growing too; consumption rose from 571.4 million tonnes of coal equivalent (tce) in 1978 to 1.38948 billion tce in 1996. But they then started to decrease slowly in 1997 and 1998.

China is rich in energy resources, with reserves amounting to 4.5 trillion tonnes of coal, 94 billion tonnes of oil and 38 trillion cubic metres of natural gas – and hydropower resources of 676.8 million kilowatts. China is the world's greatest producer and consumer of coal. In 1949 coal accounted for 96.3 per cent of energy production, and 95.1 per cent of consumption. By the 1990s these proportions had been reduced, but still remained above 70 per cent.

Several problems affect energy use. First, despite the large reserves, the size of China's population means that its energy resources per capita are lower than the world average. Proven reserves of coal and hydropower, for example, account for 11.0 and 13.2 per cent of the Earth's total – but on a per capita basis they are only 45.5 and 55.1 per cent of the world average. Per capita proven reserves of oil and natural gas are even lower, amounting to only 10.7 and 5.0 per cent of the world average.

Second, per capita energy consumption is similarly low – at only about half the world average – despite the large total amount of energy production and consumption in China. Per capita consumption of coal is higher than the world average – since it is so much the country's major energy source – but the figure for oil, natural gas, and electricity is far below it.

Uneven distribution

Third, energy resources are distributed very unevenly in China. The west of the country has 82 per cent of its hydropower resources; the north has 84.2 per cent of its coal and 76.7 per cent of its oil and natural gas resources. On the other hand, the east and central-south parts of China – which produce 57 per cent of the country's GDP, and account for 43.4 per cent of its total energy consumption (including 44.7 per cent of coal consumption and 50.6 per cent of electricity consumption) – have only 11.6 per cent of its energy resources. This imbalance requires coal to be transported from the north to the south, and electricity to be transmitted from the west to the east. The lack of capacity to transport coal is a serious constraint on economic development. ▸

Fourth, the efficiency of energy use is low. The energy intensity of China's economy has decreased significantly, but it is still several times higher than in industrialized countries, with a high level of energy consumption for each unit of industrial output. The efficiency of energy technologies falls far below the levels in industrialized countries, especially in industries that consume a lot of energy and have a high energy intensity. Many of China's industrial sectors are still dominated by small-scale and inefficient modes of production.

Fifth, the carbon intensity of primary energy sources is higher in China than in other countries, because of the importance of coal. In 1990, China's carbon dioxide (CO_2) emissions amounted to 2.384 billion tonnes, one tenth of the world total – though per capita emissions were only half the world average. Coal burning is also the main cause of air pollution in China. In all, approximately 75 per cent of the country's air pollutants come from the burning of fossil fuels.

The Chinese Government has, for many years, been adopting a series of administrative, economic and technical measures to raise energy efficiency and reduce energy consumption, while promoting economic development. In 1980, it defined the general principle for energy as 'putting emphasis on both energy exploration and saving, with energy saving as the first priority'. Since the 1980s, it has formulated and implemented approximately 30 laws and regulations concerning energy conservation.

In the early 1990s the *Outlines of Technical Policy of Energy Saving* were formulated to guide the development and application of energy-saving technologies, while the Energy Conservation Law came into force on 1 January 1998. In March 1993, the State Council approved China's Agenda 21 – *White Paper on China's Population, Environment, and Development in the 21st Century* – one of the world's first national Agenda 21s. The concept of sustainable development penetrates through the Agenda's action plans, including those for energy and the environment.

The Government has significantly reduced subsidies for energy consumption in order to raise the efficiency of energy use. Coal subsidy rates fell from 61 per cent in 1984 to 11 per cent in 1995: petroleum subsidy rates dropped from 55 per cent in 1990 to 2 per cent in 1995. Interest rates on capital loans provided by the state for constructing energy efficiency projects are 30 per cent lower than those on commercial loans, while half the interest on state loans for efficiency technological renovation projects is subsidized.

Hartmar Schwarzbach/Still Pictures

The Chinese Government has been adopting a series of measures to raise energy efficiency and reduce energy consumption, while promoting economic development

Implementing these policies has achieved significant progress in improving the energy structure and reducing energy use and CO_2 emissions. In 1980 China's energy consumption was 13.34 tce per 10,000 yuan RMB. This was reduced to 10.2, 6.78, 5.88 and 4.89 tce in 1985, 1995, 1998, and 1999 respectively. The energy intensity of GDP was thus 33.5 per cent lower in 1995 than in 1985: as a result about 660 million tce of energy was saved that year. Between 1995 and 1999, furthermore, energy intensity was reduced by another 32.45 per cent. In all, energy consumption per 10,000 yuan RMB decreased by 64.7 per cent between 1980 and 1999, saving 2.3 billion tce. It is estimated – using the average emission factor for fuel in China of 2.374 tonnes of CO_2 for each tce – that CO_2 emissions in 1995 were 1.57 billion tonnes less than they would have been had the energy intensity remained at its 1985 level. The equivalent reduction in 1999 compared to the energy intensity of 1980 is 5.4 billion tonnes.

Statistical data for recent years show that energy consumption has grown more slowly than the economy: between 1990 and 1996, the elasticity ratio of energy consumption ranged from 0.36 to 0.66. In 1997 and 1998, moreover, energy consumption actually decreased, producing a negative elasticity ratio.

Reduced emissions

Between 1985 and 1995 the proportion of coal in primary energy consumption decreased by 1.2 percentage points: this slight change cut CO_2 emissions by 36.2 million tonnes. Between 1996 and 1999 total energy consumption decreased by 7 per cent: coal burning fell by 14.7 per cent (corresponding to 214 million tonnes), while the consumption of oil, natural gas and hydroelectricity increased by 20.75, 14.47, and 8.3 per cent respectively. This led to a reduction of 8.8 per cent in CO_2 emissions between 1996 and 1999. Within this, the improvement of the energy structure led to a cut of 47.66 million tonnes. Turning coal into other kinds of energy sources like electricity, heat, gas and coke helps to raise the efficiency of energy use, to reduce CO_2 emissions and to alleviate environmental pollution. The amount of coal processed and transformed increased from 31.12 per cent in 1985 to 50.4 and 56.49 per cent in 1995 and 1998 respectively. The proportion used for electricity generation increased from 20.15 per cent in 1985 to 32.28 per cent in 1995 and 38.22 per cent in 1998.

Increasing the proportion of liquefied petroleum gas, natural gas, coal gas and electricity in residential energy use

is an important measure for alleviating urban air pollution and reducing CO_2 emissions. As the population increased, residential energy rose by 24.27 million tce between 1985 and 1995. Between 1995 and 1998, the population of China grew by another 3 per cent. However, the improvement of the structure of energy consumption cut the proportion of residential coal burning from 61.4 per cent in 1995 to 44.1 per cent in 1998, reducing the amount of coal burned by about 47 million tonnes. As a result, despite continued population and economic growth, residential energy consumption decreased by 11.4 per cent and emissions of CO_2 by 13.6 per cent between 1995 and 1998. Energy consumption by industry accounted for 66.65, 73.33 and 71.41 per cent of the country's total in 1985, 1995 and 1998 respectively. Industrial sectors are therefore the major consumers of energy and biggest emitters of CO_2 in China. The Chinese Government always gives priority to energy saving in industry and has taken a series of economic, technical and administrative measures to promote it. Energy consumption per 10,000 yuan RMB of industrial GDP has been decreasing continuously as a result. It fell from 36.97 tce in 1985 to 19.85 tce in 1995 – falling by an average 6.4 per cent a year. Between 1995 and 1998, the rate of decrease accelerated to 11.6 per cent annually.

Wu Xiaoqiang/UNEP/Topham

Rural development

There are still problems of relative energy shortage in many rural areas. About 60 per cent of rural households still rely on firewood, straw and stems for energy. The Government has worked hard to popularize firewood-saving stoves and coal briquettes and to develop small-scale hydroelectricity and other types of renewable energy. As a result, 24.76 million tce were saved in rural areas between 1985 and 1995, while 1.09 million tce of renewable energy were developed. This reduced CO_2 emissions by 59 million tonnes. In 1998, the exploitation of renewable energy amounted to 29.14 million tce, corresponding to a 68.8 million tonne reduction in CO_2 emissions.

In conclusion, implementing energy-related policies during the 1985-1995 period reduced the annual rate of increase of CO_2 emissions by 4.82 percentage points. The decrease of energy intensity over that decade cut emissions by 1.57 billion tonnes. The even greater decrease over the 1980s and 1990s as a whole cut them by 5.4 billion tonnes. This shows the great effort the Chinese Government has made to reduce CO_2 emissions so as to mitigate the impact of climate change ■

Acknowledgement: thanks to Professor Liu Xueyi of the Energy Institute of the State Development and Planning Committee for kindly providing energy conservation and related data.

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WINDS of change

SVEND AUKEN describes the role of wind power in Denmark in moving towards a sustainable energy future

Andy Mackenzie/Still Pictures

In the summer of 2002, 80 wind turbines will rise from the waves of the North Sea, 14 kilometres off the west coast of Denmark. Collectively they will form a large-scale wind farm that will provide electricity for 150,000 Danish families. They will both form a natural continuation of the last 25 years of wind power development in Denmark, and open a new era of sustainable energy supply.

Sustainable energy is a key issue in the overall discussion on sustainable development. It is obvious that the supply of energy is intimately related to sustainable development in terms of economy and social welfare as well as the environment. Everybody will probably agree on that. But differences of opinion begin when it comes to defining the balance to be reached between the three aspects.

Many would agree that we are not on a sustainable energy path, but they would do so on completely different grounds. Most developing countries would be referring to the widespread lack of access to energy and to the fact that there is no clear prospect of providing it in the near future. Many industrialized countries would argue – as I do – that the long-term perspective of climate change makes it inconceivable to continue business as usual. Others would stress the perspective of running out of an adequate supply of fossil fuels. So, we all realize the need to change.

Determined and long-term political commitment can bring down costs and create new markets

Let me present my perspective. Climate change means that the industrialized countries have to move vigorously towards cutting their emissions of greenhouse gases. We need very substantial cuts over the next few decades to make room for the aspirations of developing countries, which will inevitably lead to their emissions rising in coming years.

The first part is fairly straightforward: we need to save energy and improve our end-use efficiency as well as the efficiency of the conversion sectors. The many opportunities to save energy and increase efficiency represent a classical win-win situation – or even a win-win-win one, since we address scarce fossil resources, expenditure on energy and climate change at the same time.

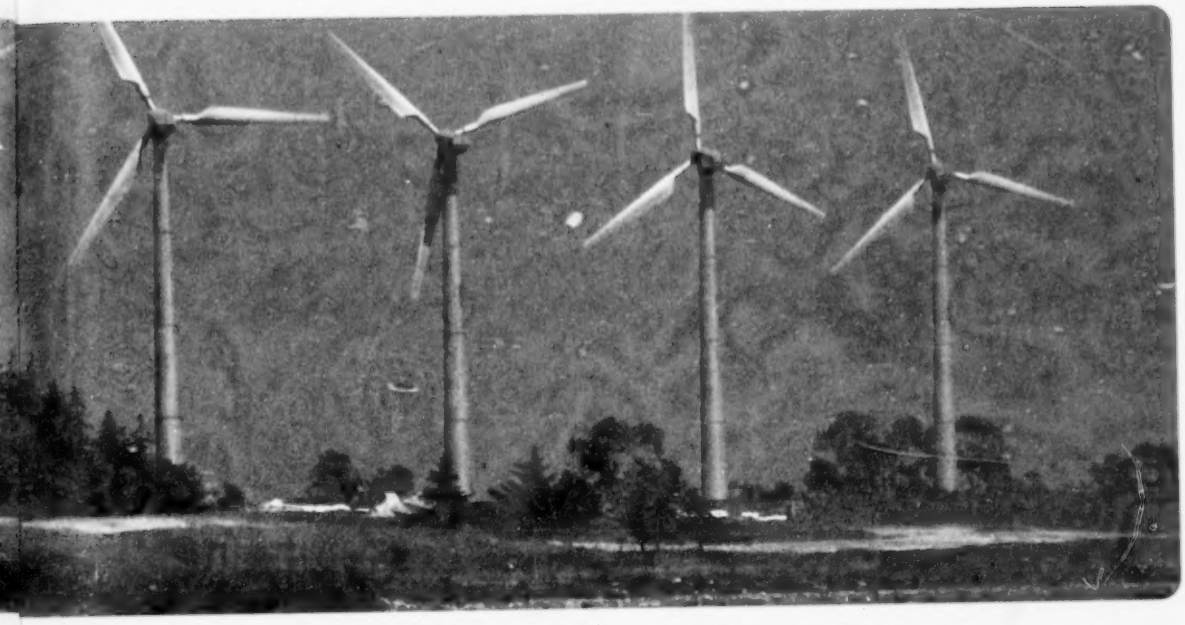
Long-term frameworks

But realizing them will only bring us part of the way towards de-coupling our use of energy from overall economic growth and cutting down emissions of greenhouse gases. The real challenge is to create long-term national and international policy frameworks for energy, which will move us completely away from our dependence on fossil fuels and allow us to create a future with much lower emissions of greenhouse gases from our use of energy.

We need incentives, opportunities and support for a sustained effort to explore the sustainable use of renewable energy resources, develop the technologies to do so, and bring them to the market place. And if we do not face up to our common obligation to develop and provide the technology and finance to build a sustainable energy future for developing countries, we can forget all about mitigating climate change. Danish energy policies have for the last 20 years been moving forward along these lines.

Savings and improvements in efficiency have made it possible for Denmark to keep the use of energy stable over the last 30 years while our economy has grown by 75 per cent. As an important part of curbing and reducing Danish emissions, we have had a major drive for renewable energy – mainly wind power and biomass.

Wind energy today provides for 13 per cent of Danish electricity consumption. More than 6,200 wind turbines have been erected since the early 1980s, with a total capacity of 2,350 megawatts (MW). In just two years from now, we expect wind power to supply more than 20 per cent of our electricity needs. Today, wind generators



at the best sites can deliver energy at the same price as coal-fired plants – and there are more cost reductions to come.

In 2000, Danish wind-turbine manufacturers supplied turbines with a rated capacity of some 2,100 MW, accounting for half the world market, with a turnover of some $1.6 billion. From 1994 to 2000 the wind industry grew at a rate of some 40 per cent per annum, while growth rates of around 20 per cent per year are forecast for the first decade of the new century. Wind-turbine manufacturing, maintenance, installation and consultant services account for some 16,000 jobs in Denmark, while component supplies and installation of Danish turbines currently create another 6,000 jobs worldwide.

All in all, the facts on Danish wind power are impressive. But how did it come about?

Consistency in policy

Plant and equipment have very long lifetimes in the energy sector. Therefore, a long-term planning horizon – currently set at the year 2030 – is considered important to ensure consistency in policy, and to send strong signals to market actors about the policy scenario in which they will operate.

Another important issue is market development. In the early 1980s, the Danish Government instituted a number of market development schemes, originally funding 30 per cent of investments in new wind turbines, but gradually lowering this support until it was abandoned in 1989. During the 1990s fixed prices and production subsidies were used to nurse the market. In the future this pricing system will be changed to a market system, where wind turbines will receive a market price plus green certificates. This change should be seen as recognition of wind power as a proven technology in the future electricity markets.

A type-approval scheme for wind turbines was established in the late 1970s at the National Laboratory at Risoe to ensure that Government-subsidized turbines had a certain level of quality and safety. Risoe today has an important research department for wind energy, with some 50 scientists and engineers employed in research on aerodynamics, meteorology and wind assessment, structural dynamics, advanced materials and related areas.

The policy to promote wind power in Denmark has been a challenge for municipal and regional planning, given the country's high population density. For the past few years, Danish municipalities have been required to make plans for siting wind turbines. Sites for more than 2,600 MW have been made available after the recent round of planning, with extensive hearing procedures for local residents.

The lesson is first and foremost that it can be done. Determined and long-term political commitment can bring down costs and create new markets for technologies supporting sustainable development.

There are already numerous opportunities for pursuing renewable energy. Many new technologies are in the pipeline – and we need a vigorous effort to bring them to the market in due time.

The future development of wind power in Denmark will be mainly offshore. Although replacing old turbines leaves room for increased capacity, very little space is left on land for new installations.

Watch the seas around Denmark in the coming years to catch a glimpse of the first large-scale offshore wind farms in the world ■

Svend Auken was Danish Minister for the Environment from 1993 to 1994, and Minister for Environment and Energy from 1994 to 2001.

POWER and CHOICE

GERD LEIPOLD says that choosing a massive expansion of renewable energy would increase security, reduce poverty, and restore economic confidence as well as tackling climate change

As we face up to the increased insecurity and slowing global economy caused by the terrorist attacks of 11 September 2001, tackling climate change may appear to be a separate goal. Yet, as environmentalists, we know all things are connected. These issues are directly and critically linked. If we are serious about tackling any of them we have to tackle them all.

The British Prime Minister, Tony Blair, recently asked 'what is the lesson of the financial markets, climate change, international terrorism, nuclear proliferation or world trade?' He answered himself: 'It is that our self-interest and our mutual interests are today inextricably woven together – that power, wealth and opportunity must be in the hands of the many, not the few.'

If we adopt a visionary and robust approach to tackling climate change we will also bring about real security, provide a boost for the economy, reduce poverty and make the world fairer.

Massive expansion of wind and solar power – and other sources of renewable energy – would provide the energy security we so urgently need. We can replace both the fossil fuels that cause climate change and nuclear reactors with their dangerous legacy. In bringing renewable energy to the world's 2 billion poorest people we would reduce poverty, help fight disease, facilitate education, give hope and independence – and make a better environment for everyone, everywhere.

Politicians, commentators and scientists the world over have described climate change as the most pressing environmental issue of the day. But it is not limited purely to the agendas of environment departments. Of course it has environmental effects – including floods, drought, dying coral reefs, melting Arctic and Antarctic ice and sea-level rise – which will both directly and indirectly affect people and economies. But its causes go to the heart of industrial society and its energy supply, almost entirely dependent on fossil fuels. Tackling climate change means phasing these out.

The United Nations Framework Convention on Climate Change committed governments to the 'stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system'. The United Nations also identified ecological limits that are already being stretched, if not broken, as ecosystems show signs of stress.

Sobering statistics

If we are to stay within these limits, the amount of carbon in the atmosphere must be restricted over the longer term to a maximum of 400 parts per million of carbon dioxide equivalent. Present estimates – which depend on the numbers of forests cut down and replanted – allow us a carbon budget of between 145 and 260 billion tonnes.

The central estimate of the 'carbon budget' of 225 billion tonnes is only a quarter of existing economic reserves and is a very small fraction (5 per cent) of the estimated resource base of oil, coal and gas.

Even more sobering, at the current rate of fossil fuel use, this budget will be exhausted in less than 40 years. And if energy demand continues to grow at the present rate of 2 per cent per year, it would last for less than three decades.

Photo: Photonet NEP Graphics

The deal finalized at Marrakech in November means there should be no further obstacles, real or imagined, to all Parties ratifying the Kyoto Protocol. All – including the United States – should do so now to bring it into force by next September's World Summit on Sustainable Development. But while it is a valuable first step, the Protocol only calls for a cut of just over 5 per cent from industrialized countries; and even this is so riddled with loopholes as to allow emissions to increase.

The timetable for negotiations on the second commitment period needs to be accelerated and targets set

to ensure that industrialized countries are fixed on an emissions trajectory that would have them reduce emissions by at least 80 per cent by 2050.

The scientific logic of what we have to do to achieve this is inescapable. We must begin a rapid reduction of the use of fossil fuels, leading to a phase-out within a generation. That means that the world's energy needs must be met from clean, renewable sources.

Sean Sprague/Still Pictures

For 30 years Greenpeace has spread the vision of a peaceful and secure world. This is now needed more than ever to guide the world away from terror and war and towards the kind of security that comes from everyone being liberated from hunger, poverty and disease – with clean water to drink, pure air to breathe, uncontaminated food to eat and freedom to live without fear. We plead for a new kind of peace, one that is based on providing people with the basic securities of life so that terrorism can take no hold, and one that strives to build a world where interdependence signifies productive mutual need, rather than fearful apprehension.

We need to discard dangerous technologies such as nuclear power and the production of toxic materials. We must abolish all biological, chemical and nuclear weapons. Meanwhile, a massive increase in renewable sources of power would counter the inequality created by gross poverty.

Precarious rights

Over 2 billion people have no access to reliable electricity. Millions more live in poverty and squalor. The impacts of climate change identified in the Third Assessment Report of the Intergovernmental Panel on Climate Change pose a serious risk to development, particularly in the poorest areas of the world. Basic rights such as reliable access to food, water and health care are likely to become more precarious as global warming accelerates. Extreme weather events are already killing, or rendering homeless, tens of thousands of people every year.

Our dependency on fossil fuels is also perpetuating conflicts over resources. Ongoing and increasing reliance on environmentally destructive energy sources only increases the power of the few over the many, and so increases instability. We have to break the hold which the current energy suppliers have over society.

We have to break the hold which the current energy suppliers have over society

The G8 Task Force on Renewable Energy showed in its recent report that the barriers to the large-scale uptake of renewable sources of energy are not technological, but financial and political. Its principal finding was that 'renewable energy resources can now sharply reduce local, regional, and global environmental impacts as well as energy security risks, and they can, in some circumstances, lower costs for consumers'.

It concluded that investing $250 billion over ten years would provide renewable energy to 1 billion people – 200 million in the OECD countries and 800 million of the world's poorest.

Similarly, *The Solar Generation*, a new report from Greenpeace and the European Photovoltaic Industry Association, predicts that solar could provide 2.3 million jobs globally by 2020, and provide energy to 1 billion people worldwide, given sufficient government and industrial support. A global campaign to convert our energy economies to renewables would create jobs and, with them, the confidence increasingly lacking in the global economy.

We need global political intervention to fight climate change on a par with the massive and rapid commitment of resources and prioritization that the world has recently seen in response to acts of terrorism.

The 11 September marked a moment of choice. Will we finally address the instability and insecurity born out of inequality, or continue down the path to more pain and suffering?

Conventional wisdom dictates that there is no choice but to continue our dependence on fossil fuels with all the instability and damage that it brings.

But there is a choice. Switching to renewable energy would cause a significant shift in power, create millions of jobs, reduce fear and anxiety and effectively combat climate change, the single greatest threat to the planet ■

Gerd Leipold is Executive Director of Greenpeace International.

RISING SUN

JEREMY LEGGETT argues that solar energy could meet most of the world's needs within a decade

Twenty years ago, at the time of the second oil price shock, Sheikh Yamani, the Saudi Arabian oil minister, warned his fellow OPEC ministers: 'If we force western countries to invest heavily in finding alternative sources of energy, they will. This will take them no more than seven to ten years.'

The world then chose not to invest in renewable energy. It remains dwarfed by oil, gas and coal, even though we have been warned for most of the ensuing period that if we continue burning so much carbon-based fuel we will unleash economically and environmentally ruinous global warming. But it could, in principle, provide most of the world's power and transport needs within as little as a decade.

Creative solutions

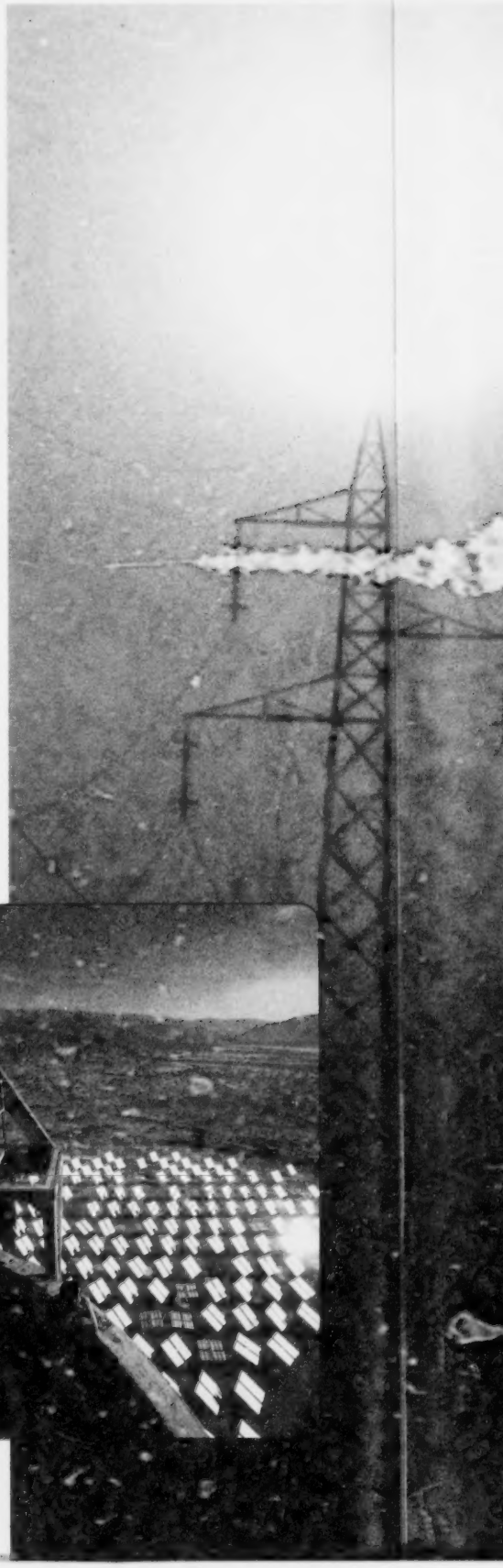
In every region of the world, innovative application of new solar technology is providing high-tech, emission-free and creative design solutions. In the developing world these are beginning to bring clean energy to remote rural communities that have traditionally relied on candles, wood and paraffin. The 2 billion people who now lack electricity could have their needs met by micropower technologies, avoiding the need for new, polluting, costly and centralized grid infrastructures.

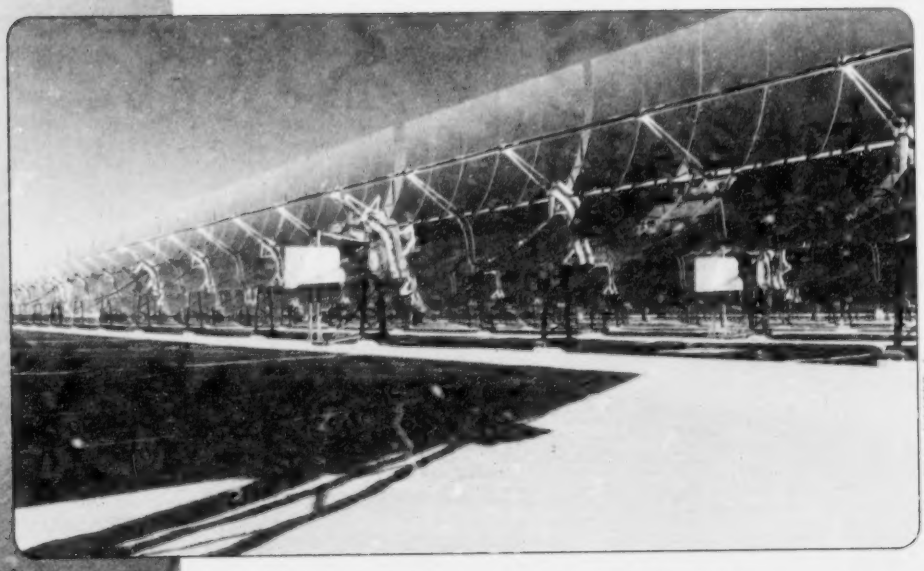
From Cyprus to Sweden, from China to Australia, new markets and new manufacturing capacity are helping to make solar photovoltaics (PV) a global industry. Just one manufacturer, Sharp, is producing 94 megawatts (MW) per year. The resulting huge economies of scale in manufacturing will play a major part in ensuring the long-term health of the industry.

In the United Kingdom, Solar Century and other domestic solar companies have completed many commercial, industrial and household solar PV projects with partners including Sainsburys, Grange and Laing.

A way to go

But there is some way to go before solar PV is viewed universally as an automatic mainstream energy option rather than a niche alternative appropriate only for local community projects or one-off prestige buildings. *The Solar Generation*, the recent report by the European Photovoltaic Industry Association and Greenpeace, demonstrated that the global solar PV industry could be on the verge of an unprecedented boom in both the developed and developing worlds. Its projections indicated that solar PV could easily supply electricity for over 1 billion people, including 30 per cent of the entire continent of Africa, and provide 2.3 million jobs by 2020. By 2040, it could provide 26 per cent of total projected global energy demand.





Solon Architekt/NEPTune

France Sauvaget/NEPTune

The global solar PV industry could be on the verge of an unprecedented boom in both the developed and developing worlds

If we are to meet and ideally beat these targets, the industry will need to redouble its efforts to break down barriers of ignorance, vested interest and short-termism. As the G8 Task Force on Renewable Energy report concluded, the barriers are essentially financial and political, not technological. We must improve education and awareness of our products and their application. Political and institutional inertia is our greatest enemy.

Unrecognized potential

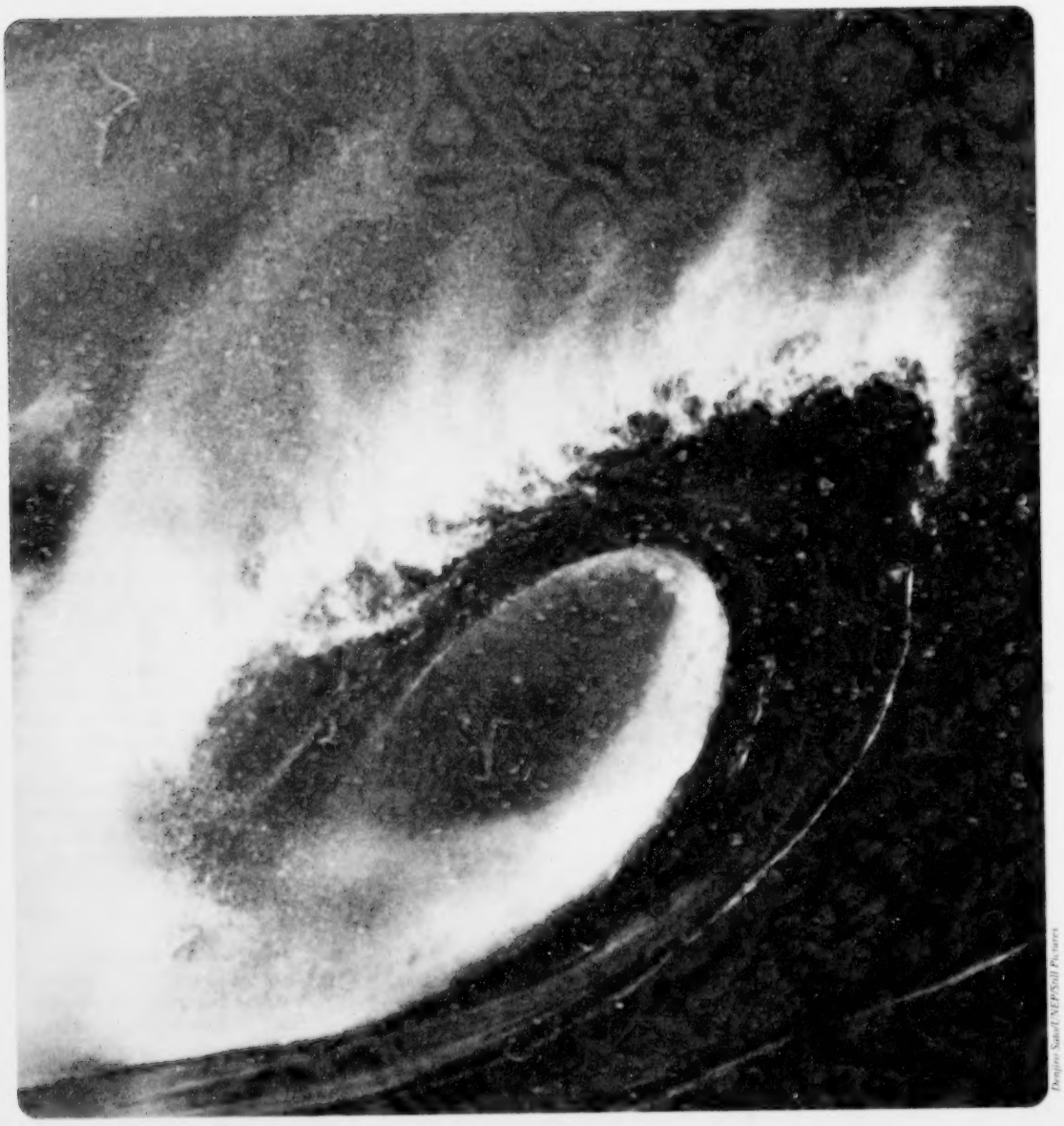
If anything, these long-term targets underestimate the potential of solar PV to become a mainstream energy option in the first decade of the 21st century. They assume, for example, the implementation of welcome but modest national support programmes in OECD countries – such as the 70,000 solar roofs programme currently under way in Japan, which is projected to spend just $195 million in 2002. In fact the 2020 and 2040 projections could be achieved far earlier if the necessary practical steps are taken now by policy-makers and regulators.

San Francisco provides both an inspiring and practical benchmark for European legislators. As a result of a $100 million bond issue and other local initiatives, the city could produce up to 20MW of solar PV electricity within 12 months, with the prospect of an additional 50MW over the next three years – five times what the United Kingdom, for example, projects for 2004/2005.

Security and diversity

The appalling events of 11 September 2001 and their aftermath have inevitably refocused policy-makers' attention on the need for energy security and diversity. In the run-up to Rio+10, national governments will be reminded by non-governmental organizations and others of their Kyoto commitment to deliver 'development and increased use of new and renewable forms of energy'. With a strategic and long-term approach, and sufficient resources, renewable micropower technologies could grow explosively, rapidly eating into the $2 trillion global energy market ■

Jeremy Leggett is Chief Executive Officer of Solar Century.



Benjire Sakol/NEPSill Pictures

Give us **A WAVE!**

DAVID ROSS says that the immense potential of wave power is on its way to being realized

Wave energy has been hailed as the most promising renewable source for maritime countries. It does no environmental damage and is inexhaustible – the waves go on for ever. It is invariably popular with the public, which has a sentimental love of the sea.

The potential resource is vast. It is usually estimated as being of the order of 2,000 gigawatts (GW), though UNESCO has put it at roughly double that amount. But what we need to estimate is how much can be gathered and delivered at an economic price. Getting energy from the

aves has been studied since the time of the French evolution when the first patent was filed in Paris by a ther and son named Girard. They noted that 'the normous mass of a ship of the line, which no other nown force is capable of lifting, responds to the slightest ave motions'.

There was little progress in turning those motions into seful energy until the last quarter century, mainly through ck of scientific knowledge of what a wave was, how it avelled and how it could be converted. There was also a ell-deserved respect for the formidable nature of the task, nd the considerable capital needed was not available.

Unlike hydro-electric power it cannot draw on the flow f water running in one direction. You cannot put a water heel in the sea and leave it to revolve and generate lectricity, even though, to the watcher on the shore, it ppears that the waves are advancing towards the beach in a traight line. Leonardo da Vinci noted that when the wind lew across a field of corn, it looked as though waves of orn ran across the field – whereas, in fact, the individual eads were only moving slightly. So it is with waves in the ea, which can also be compared with the movement of a kipping rope. As one end is waggled, a wave form travels o the other – but the rope itself does not advance.

Elusive power

A wave travels forward in an elusive, up-and-down motion. ts height is the key indication of its power. So the rougher he sea, the more potentially fruitful it is – but also the harder it is to harvest. So wave energy engineers have to design a power station that can absorb the power of the most ferocious waves without being wrecked. Two, in Scotland and Norway, have already been victims of the sea.

Yoshio Masuda, from Japan, invented the oscillating water column (OWC) – effectively a chimney which stands on the seabed and admits the waves through an opening near to its base. As they rise and fall in the open sea outside, the height of the column of water inside rises and falls too. As the water level rises, air is forced up and out through a turbine which spins and drives the generator. As it falls again, air is sucked back in from the atmosphere to fill the resulting vacuum and once again the turbo-generator is activated.

Professor Alan Wells of Queen's University, Belfast, greatly improved the efficiency of the invention by devising a turbine which spins in the same direction regardless of whether the air is being pushed out or sucked back into the chimney.

Norway launched a wave energy station on the coast close to Bergen in 1985, which combines an OWC standing facing the waves, with a Norwegian invention called a Tapchan (from the words tapered channel). The waves ride up a concrete slope to a point 3 metres above sea level, where they splash into a reservoir. The water flows back to the ocean through a turbine which drives a generator.

Professor Stephen Salter of Edinburgh University has contributed the most intellectual invention. Salter's Duck, as it is called, looks charming and popularized the idea of

Wave energy was not devised to save money but to save the world

wave power. It is also a potential world-beater. The ducks are cones, filled with sophisticated electronic equipment, built around a spine, which bob up and down on the waves driving a generator. Salter will not let the system go to sea until he feels it is ready.

Small-scale wave power initiatives – from 100 kilowatts (kW) to 2 megawatts (MW) – are now going ahead in more than a dozen countries. Scotland had an experimental 75kW OWC on the shore of the island of Islay for 11 years: this has now been replaced by a 500kW model, named the Limpet, clinging to rocks facing waves sweeping in from 5,000 kilometres of the Atlantic.

The same group of researchers plans a 2MW seagoing device called the Osprey. Another Scottish model, called Pelamis, is a series of cylinders linked by hinged joints and hydraulic motors driving generators.

Portugal has been working for several years on an OWC on the island of Pico in the Azores. The Netherlands has invented the Archimedes Wave Swing, an air-filled 'floater' which moves up and down while its 'ground floor' sits on the seabed. An American company is working on a 10MW scheme based on buoys 3 kilometres off the south coast of Australia. India, China, Sweden and Japan are among other countries where wave energy is burgeoning.

Overcoming hurdles

The technical problems have been steadily overcome but the only practical applications have been on a small scale. Wave energy is crying out for 2,000MW power stations in the deep ocean.

The big hurdle is financial. Wave energy was not devised to save money but to save the world. Early researchers used to say optimistically that the energy was free because the gods provided the waves. Others swung to the opposite extreme by using high discount rates, which hit wave energy unfairly because it is a capital-intensive technology, where most of the expenditure is during construction. The simple way to change the costing is to change the discount rate.

The energy establishment has not been helpful; it naturally did not welcome a new rival for its markets. Governments and companies emphasized conventional costing. A leading Netherlands inventor commented: 'The financial engineering is even more difficult than the technical engineering. In our team, we call it emotional engineering.' But, for the first time for 30 years, the breakthrough is now in sight. Wave electricity will be on the grid in many countries before long ■

David Ross is author of Energy from the Waves *(Pergamon, 1979),* Power from the Waves *(Oxford University Press, 1995) and* Scuppering the Waves *(Open University Network for Alternative Technology, 2001).*

Less energy, more wealth

Ernst von Weizsäcker

Energy consumption rose hand in hand with economic growth during industrialization. This cannot go on forever. Energy, after all, is a limited resource while economic growth can, theoretically, continue indefinitely.

Fossil fuels may last another 200 years, and their use causes global warming. Uranium has little more than 150 years, and nuclear power meets endless resistance. The feasibility of fusion power remains doubtful, and massive neutron and tritium flows make it an uncomfortable neighbour to nuclear fission. Renewables will grow but may well also run into environmental conflicts in the process: think of controversial large dams, fuel crop monocultures or protests against wind power 'parks'.

High energy consumption is also politically risky. Consider the military expenses the United States and other countries incur to 'secure' their access to the Middle East and Caspian oil resources. And think of the vulnerability of large power plants – and the entire nuclear fuel 'cycle' – to terrorism and war.

Greater productivity

Fortunately, we are much less dependent on energy than we think. Energy productivity – the amount of wealth we can extract from a barrel of oil or 1 kilowatt-hour – can be increased ten-fold, at least. This may sound daring, but consider this: just one kilowatt-hour, in theory, is sufficient to lift a 15-kilogram rucksack from sea level to the top of Mount Everest twice over.

Energy productivity is high-tech, it is modern and it normally pays. A book I co-authored with Amory and Hunter Lovins (*Factor Four – Doubling Wealth, Halving Resource Use*, Earthscan, 1997), features 20 examples where energy productivity has been quadrupled.

Bill O'Connor/Still Pictures

One is Amory Lovins' 'hypercar' which is expected to consume 1.6 litres per 100 kilometres travelled. Others are buildings that need one quarter or one tenth of the energy of today's standards to heat and cool them. Household appliances, light bulbs, air conditioners, pumping systems, office equipment and food are also covered.

What was perhaps a trifle outlandish when the book was written has now reached the market. Energy-efficient buildings have become standard in countries with reasonably high energy prices, while the auto industry has become much more interested in fuel-efficient cars.

Most encouraging, perhaps, is China's achievement in reducing its overall annual carbon dioxide (CO_2) emissions for three consecutive years despite 7 per cent economic growth rates – mainly by closing highly wasteful factories and replacing them with energy-efficient ones. Under prevailing Chinese conditions, it is estimated, reducing each tonne of CO_2 emissions by increasing energy efficiency saves $10, while doing so by substituting renewable energy for coal may cost $10.

Incentives for change

When UNEP's Executive Director, Klaus Töpfer, was German Environment Minister, the country introduced powerful incentives for power generation from wind, small hydro, biomass and photovoltaics. Utilities were forced to compensate small electricity suppliers at rates that fully or nearly covered the cost of production. The incentives were strengthened by the 'red-green' Government after the 1998 elections. Now, Germany is the world's top producer of wind energy and a major player in photovoltaics (which received an additional push from a state-subsidized 100,000 roofs programme).

Sweden has long applied building codes for homes and offices with ambitious energy efficiency goals. Manufacturers cooperate with public authorities on efficiency standards for household appliances.

Green taxes have been introduced in most countries of the European Union, though they are far from being popular. Internationally, the most significant development is the beginning of a CO_2 emissions trading system – though it is too early to judge its impact.

Anticipating success

We, at the Wuppertal Institute, like to compare the current and future development of energy productivity with the development of labour productivity during the Industrial Revolution. When James Watt's steam engine heralded the Industrial Revolution, productivity was deplorably low – but it increased 20-fold over two centuries. Today, the really scarce resource is not labour, but nature. It would be wise, even inescapable, to concentrate now on increasing resource – especially energy – productivity. Maybe, in 200 years similar successes will be reported in this fascinating field of technological progress ■

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